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## CONTENTS

The Editor's Page ..... 142

X-ray Analysis of Textile Fibres. Part IV. Wayne A. Sisson, *Fellow of the Textile Foundation* ..... 143

The Quantitative Determination of Stiffness in Individual Yarns. Irving J. Saxl ..... 152

Micro-analysis of Textile Fibres. Part V. G. Gordon Osborne, *Fellow of the Textile Foundation* ..... 157

Abstracts ..... 174

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# The Editor's Page

## Rayon Crêping Conference Report

SO many of those who attended, or are interested in, the open conference on rayon crêping problems, held Nov. 14 under the Institute's auspices, have received mimeographed copies of the discussion that it has been decided that it will be unnecessary to publish it in this issue. All salient features of the discussion were covered in the summary of Chairman Smith, published in the December issue. However, any who may wish a complete copy of the discussion may obtain it by addressing Secretary Clark.

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## Research on Rayon Crêping

THE joint committee of the Throwsters Research Institute and the American Association of Textile Chemists and Colorists having charge of the study of rayon crêping has practically completed its research program, and hopes to select its director and place or places for the study in time to start work early this month. Excepting for certain details of the program it is the same as outlined by Mr. Bishop at the conference held under U. S. Institute's auspices Nov. 14. Although several members of U. S. Institute are members of the joint committee having charge of this research, this Institute is not officially associated in the work.

Those who had accepted membership on the joint committee at this writing were the following: H. E. Bishop, B. L. Hathorne, Charles M. Epstein, George Friedlander, Dr. J. B. Quig, Dr. Irving J. Saxl, Dr. H. DeW. Smith and V. McCullum.

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## Hollow Staple Fibre

"STAPLE fibre in predetermined lengths formed of hollow filaments with sealed ends has been patented by a Lancashire chemist, Fred Ferrand, F.C.S., who has been working to develop this fibre for many years. He has so far operated a small unit at a well-known Lancashire cotton mill near Preston, Eng." The Ferrand Staple Processes, Ltd., is to control and handle the rights to the process. From *Textile World*, Oct. 1935, P. 116.

(*Editorial continued on pages 151, 156 and 187*)

# X-ray Analysis of Textile Fibres

## Part IV. A Suggested Secondary Structure for Cellulose

By WAYNE A. SISSON *

*Fellow of the Textile Foundation*

### Summary

*A concept concerning the secondary structure of cellulose, paralleling that proposed by Zwicky for inorganic crystals, is suggested in the hope that the present conflicting theories regarding the fine structure of cellulose may be harmonized. This picture may be described as a compromise between the concept of discrete micelles or well-defined crystallites on the one hand, and the existence of a continuous structure on the other. There appears to be nothing in the X-ray data to belie the concept of secondary structure for cellulose.*

### Introduction

IT has been suggested by Smekal [1] and elaborated by Zwicky [2] that the properties of solids may be arranged in two general groups:

I. Structure insensitive.
II. Structure sensitive.

Properties of the first type are practically the same regardless of the source or the macro-structure of the material; while properties of the second type vary widely, depending on the source, the macro-structure, and the past history of the material.

Since cellulose is definitely crystalline, it would appear of advantage to use a similar classification when referring to the structure and properties of cellulose.

The chemical reactions, the density, energy content, X-ray diffraction lines, etc., are practically the same for all purified cellulose fibres. These properties depend largely on the chemical structure of the cellulose molecule as deduced from organic chemistry, and on the lattice of the unit cell structure as revealed by X-rays. This chemical and crystalline structure may be designated as the "*primary structure of cellulose.*" It gives rise to properties of the first type—structure insensitive.

On the other hand, most of the important practical physical properties of cellulose fibres, such as tensile strength, elasticity, swelling, shrinkage,

* Dr. Sisson worked under the direction of Prof. G. L. Clark, University of Illinois, Urbana, Ill.

etc., vary widely among different fibres. These properties depend largely on the configuration of the cellulose crystallites, on their arrangement or orientation in the cellulose fibre, and on their association with other amorphous or non-cellulosic materials in the fibre. This structure, arrangement, and associations of the cellulose crystallites may be designated as the "*secondary structure of cellulose.*" It gives rise to properties of the second type—structure sensitive.

Concerning the primary structure of cellulose, there appears to be a fairly universal agreement among research workers, and since it has been repeatedly described in the literature it will not be elaborated further.

Concerning the secondary structure of cellulose, however, there is a wide diversity of opinion among research workers. A discussion of this lack of agreement, and also a summary of the X-ray data and its possible interpretations, and a description and comparison of the various theories for explaining the X-ray data is given in a preceding paper.[2] As pointed out, each theory of submicroscopic cellulose structure is supported only by part of the data and there is, as yet, no general fundamental theory which will explain all the known facts concerning the behavior of cellulose.

Although there is considerably more known concerning the microscopic structure of the cell wall (that it consists of a middle lamella, primary wall and secondary wall, which in turn is composed of lamellae, fibrils or other microscopic convolutions) there is likewise no general agreement among investigators as to the significance of this visible heterogeneous structure.[33]

In common with the lack of agreement concerning crystalline cellulose, there is no universal agreement regarding the fine structure of the more familiar crystals, such as rock salt or calcite. It is impossible to explain the physical properties of a single crystal on the classical theory of a continuous lattice work of ions or molecules, typical of the unit cell arrangement, extending in all directions within the external crystal form. For example, the calculated tensile strength of a sodium chloride crystal is several hundred times greater than that experimentally observed,[12] and in order to explain such large differences as this between the calculated and observed behavior of crystals, Zwicky[3, 4, 5, 6, 7, 8, 9, 10] has postulated that, superimposed on the lattice structure known from X-ray diffraction data, there is another lattice on a much larger scale consisting of crevices or cracks which give the crystal a "block" or "secondary" structure.

The suggestion which we especially wish to advance at this time is the possibility of applying a similar concept in modified form to the crystalline structure of cellulose.

Before proceeding to develop the concept of a secondary structure applied to cellulose fibres, a summary of Zwicky's theories on the secondary structure of single crystals and its consequences will be given.

## Secondary Structure of Single Crystals

According to Davey,[11] the assumption of a secondary structure superimposed on the lattice structure is not unreasonable, since it is known that the surface tension of crystals is very large and decreases with depth below the surface, and it would be impossible for this force to contract the surface as a whole; instead, the contraction would have to take place in patches with crevices separating the patches. These crevices would extend into the crystal to a rather indefinite depth at which the surface tension no

longer is large. It has been calculated that these crevices are approximately 100 Å apart and 75 Å deep for sodium chloride crystals.[6, 7] The width of the crevices must be at least the packing diameter of the ions or molecules which occupy the points of the space lattice, and the crevices are not void but are probably partly occupied by disorganized materials.

According to the above picture, a single crystal is a latticework of points (occupied by ions or molecules) on which is superimposed a coarser structure separated by crevices. Zwicky [4, 6, 7] has designated the lattice or molecular planes as "$\rho$-planes," the superimposed crevices as "$\pi$-crevices," and the walls of the crevices as "$\pi$-planes." [11] Just as the $\rho$-planes are characteristic of the ion or molecules of which the crystal is composed, so the $\pi$-crevices must be characteristic of the material, and they must run parallel to the $\rho$-planes which have the greatest interplanar spacings in the crystal.

Zwicky [21] has shown there is evidence for crevices still larger than the $\pi$-crevices. These have been designated as "II-crevices" and the walls of these supercrevices as "II-planes." [11] The II-crevices are deeper and of greater width than the $\pi$-crevices, and Zwicky has calculated that the distance between the II-planes should be 5,000 to 20,000 Å, depending upon the type of crystal.

The concept of a secondary structure appears to be consistent with the theories of crystal growth,[11, 22] and the mechanism of plastic flow [13] and the cold hardening of metals,[4] the etched figures of single crystals,[14, 23] Widmanstatten structure,[15] diffusion through single crystals,[16] the difference between lattice and macro-thermal expansion,[17] low tensile strength of crystals,[21] intensity data of diffracted X-rays,[11] etc. For example, when a metal crystal is deformed, slip takes place first on the II-planes. This causes an interlocking of the "blocks" and slip must take place next on the $\pi$-planes. Slip probably never occurs on the $\rho$-planes. This picture is consistent with the step-by-step mechanism of plastic flow, the cold work hardening effect, and the slip bands observed in deformed crystals.

On the other hand, several investigators [18, 19, 20, 21, 24, 25] have offered objections to the concept of a secondary structure applied to single crystals; yet none of these investigators have to offer in its place a theory which so satisfactorily explains the physical properties of crystals. It is true that there is no direct experimental evidence to support the existence of $\pi$- and II-crevices in crystals; but if the hypothesis of secondary structure is unnecessary, then the large-scale periodicities of crystals remain to be accounted for.

## Application of Secondary Structure to Crystalline Cellulose

If a "secondary structure," consisting of $\pi$- and II-crevices superimposed on the lattice structure, is the natural state of the more familiar crystals, and if the physical properties of these crystals are a necessary consequence of the nature of the secondary structure, then there is little reason to suspect that cellulose should be different in this respect. It is true that crystalline cellulose is a biological product and is not produced from a melt or a saturated solution; yet, this difference in origin does not entirely exempt crystalline cellulose from obeying the laws of crystal physics. Consequently, it does not seem a far cry to attempt an explanation of the physical properties of cellulose on the same basis as one would the physical properties of the more familiar crystals.

The possible analogy between the micellar structure of protein fibres and the secondary structure of single crystals has been pointed out by Astbury,[32] and it was suggested in the previous paper[2] that the imperfect crystalline structure of cellulose might be explained on the basis of Zwicky's theories. The purpose of the present paper is to develop further this suggestion, and especially to point out the possibility which it appears to offer for explaining many of the properties of cellulose and for harmonizing the present conflicting theories regarding the fine structure of cellulose.

## Crystal Growth

Although we do not as yet know a great deal about the mechanism of crystal growth in cellulose fibres, growth must certainly take place in the presence of a large amount of impurities. According to Davey,[11] when a substance crystallizes in the presence of an impurity "The chemical bond between the impurity and the crystallizing material may be (1) weaker than, (2) equal to, or (3) stronger than that between adjacent molecules of the crystallizing material. (1) If the bond is weaker, the impurity will have a greater chance of leaving the surface than the molecules of the crystallizing material. The impurity will therefore be present mostly in the form of material entrapped in the $\pi$-crevices, in the $\Pi$-crevices, or in the intercrystalline boundaries. Only a fraction of it will be left to foul the growing surface and retard crystal growth. (2) If the bond is practically equal, the impurity will enter into the structure of the $\rho$-planes after the manner of alums. (3) If the bond is stronger, either the impurity will remain on the growing surface, fouling it so as to retard growth, or the impurity will leave the growing surface, taking with it that portion of the surface material with which it is combined, and in such a case it must tend to concentrate at the $\pi$-planes, at the $\Pi$-planes and at the crystal boundaries."

Since cellulose crystallites are very small,[2] are slowly formed, and are of a definite crystalline structure, and since the X-ray data indicate the presence of some amorphous cellulose which must certainly be closely associated with the other noncellulose materials present in the fibre, it would seem that crystalline cellulose logically belongs to the latter class. The large amount of amorphous materials present during the deposition of cellulose must therefore be concentrated principally in the $\pi$- and $\Pi$-crevices and between the crystallites, and its presence must have considerable effect upon crystal growth.

The effect of impurities on crystal growth has been clearly demonstrated by Buckley.[29, 30, 31] For example, $KClO_3$ crystals grown from a pure solution, crystallize in the form of large thin plates;[30] by growing them in the presence of impurities, however, various modifications may be obtained.[31] Buckley[29] suggests that the habit-modifying properties of a foreign molecule rest in its ability to adhere to the crystal surface, or in the amount of obstruction which it would cause to the crystal-growing process after it had managed to gain a settled position on the surface, or to both factors operating at the same time. The former he has called the "adhesion" factor, and the latter, the "obstruction" factor. Organic dyes were found to have a much greater habit-modifying property than inorganic salts and, as a rule, the dye affected growth principally along certain planes of the crystal. $KClO_3$ crystals grown in the presence of certain dyes exist as very small needle-like crystals instead of the usual large plate form.

If the usual plate-like macroscopic $KClO_3$ crystals are changed to needle-like microscopic crystals when grown in the presence of organic dyes, it would seem equally logical to suspect that the large amount of non-cellulosic materials present in the cell walls of cellulose fibres during the deposition of cellulose would have an analogous effect on the crystal habits of cellulose. Perhaps the fibrils or lamellae which may be identified microscopically in mature fibres are nature's attempt at growing single crystals of cellulose; or, perhaps a single fibre is the attempt which is foiled by the large surface tension and secondary valence forces which absorb numerous impurities, and enlarge the II-planes to the extent that they, in effect, separate the cell wall into microscopic striations. The nature of the cellulose molecule should be naturally conducive to the existence of long fibrous crystals; and, furthermore, this tendency should be reinforced by the impurities which are held by the hydroxyl groups, and thus retard crystal growth in the direction perpendicular to the cellulose chains.

## $\rho$-Planes

According to Zwicky,[3] the distance L between two $\pi$-planes may be calculated from the equation:

$$L = 100 \cdot \frac{a}{\gamma}$$

where a is the length in Å of the edge of the unit cell, and $\gamma$ the percentage contraction in the lattice parameter at the surface. From the stress-strain curves of regenerated cellulose fibres (kinks and imperfections prevent an accurate determination in natural fibres) [26] the elastic range of cellulose parallel to the fibre direction is between 1 and 2%. If we assume $\gamma$ to have the average value of 1.5, and since $a$ is 10.3, we have:

$$L = 100 \cdot \frac{10.3}{1.5} = 685 \text{ Å}$$

The size of the cellulose fibre does not permit an accurate determination of the elastic range perpendicular to the fibre axis, but judging from the other anisotropic properties of cellulose it should be about 10 times as great as the value parallel to the fibre axis. Since the $\pi$-crevices parallel to the fibre axis should be parallel to the (101) or (002) planes, we have:

$$L = 100 \cdot \frac{6.1}{15} = 40 \text{ Å}, \qquad \text{or}$$

$$L = 100 \cdot \frac{5.4}{15} = 36 \text{ Å}, \qquad \text{or}$$

$$L = 100 \cdot \frac{3.98}{15} = 26.5 \text{ Å},$$

Since the edge of the unit cell perpendicular to the fibre axis does not correspond to different cellulose chains, but to a periodicity of the glucose residues along the chain, and since there is evidence of considerably longer chains than 680Å in native cellulose,[27, 28] a large surface contraction parallel to the chains would necessitate the breaking of primary valence bonds, which is a very improbable condition. It is doubtful, therefore, if there

are any large $\pi$-crevices perpendicular to the cellulose chains. However, the tendency for these $\pi$-crevices to form should exist, and the surface tension should cause $\pi$-planes to form definite interval breaks along the cellulose chains during the degradation and dispersion of cellulose. In the direction parallel to the unit cell, however, one would expect well-formed or deep $\pi$-crevices to exist. These crevices should have a minimum width corresponding to the packing diameter of the cellulose chain (between 4 and 8.5 Å) and perhaps much larger.

## II-Planes

As previously mentioned, Zwicky has predicted the existence of II-planes even in cubic crystals such as sodium chloride and the common metals. Owing to the long fibrous nature of the cellulose chain and the large number of hydroxyl groups extending from the chain, one would expect II-planes to be much more pronounced in cellulose, especially in the direction parallel to the cellulose chains. Because of the lack of sufficient data, however, it is not possible to calculate the probable distance between the II-planes in cellulose. Zwicky [7, 3] has estimated that for most crystals the distance between II-planes should be between 5,000 and 20,000 Å; the tendency being for heterpolar crystals to favor the lower end of the scale, whereas homopolar substances will have larger spacings. The relative distances between the II-planes, as a rule, are proportional to the corresponding dimensions of the unit cell.

As in the case of the $\pi$-planes, one would not expect large II-planes perpendicular to the cellulose chains. Parallel to the cellulose chains, however, one would expect very pronounced II-crevices which would be occupied by the large amount of amorphous materials present in most cellulose fibres. If the mechanism of crystal formation in the presence of impurities postulated by Davey and by Buckley may be extrapolated to the deposition of crystalline cellulose, then it would not seem unreasonable to suspect that the II-planes form the boundaries of the cellulose crystallite in the direction parallel to the cellulose chains. Since the diameter of the fibril is within the distance between II-planes postulated by Zwicky,[7, 3] it is possible that the boundries of the lamella and fibrils are analogous to the II-planes existing in the more familiar crystals.

## Relation of Secondary Structure to Physical Properties

The concept of a secondary structure may be classified as a compromise between the concept of discrete micelles or well defined crystallites on one hand, and the existence of a continuous structure on the other. A secondary structure postulates a more or less continuous structure, but at the same time the crystalline regularity is intercepted by well-defined $\pi$- and II-crevices occupied by non-crystalline material which serve as boundaries for crystalline aggregates corresponding to lamellae, fibrils, crystallites, micelles, cellulose-chain aggregates, macromolecules, etc. The crystalline surface may be roughly compared to the surface of a dried pond (covered with cracks and crevices) with the exception that the principal crevices run parallel to the cellulose chains and are partly occupied by amorphous material.

*X-ray Data:* There is nothing in the X-ray data to belie the concept of a secondary structure for cellulose. All of the characteristics of the X-ray diagram listed in Part III * are satisfactorily accounted for by as-

* *Tex. Rsch.*, 4: 286–302 (1934).

suming the existence of well-defined $\pi$- and II-planes parallel to the cellulose chains. The II-planes should have the same effect in producing Debye-Scherrer diagrams as would the well-defined crystalline boundaries of micelles or crystallites, and the distortion due to the contraction of the surface to form the $\pi$-planes should produce the same broadening of the X-ray diffraction lines as would the existence of a strained lattice or of a small micellar size. Due to the small volume of crystalline cellulose within the II-plane boundaries, the percentage of contracted surface should be large enough to produce the observed cellulose-line-breadth characteristic of cellulose.

*Dispersion and Degradation:* A satisfactory explanation of the mechanism of cellulose dispersion and degradation is rather difficult on the basis of a micellar theory. If discrete micelles exist in native cellulose, then it should give a more or less uniform micellar size upon dispersion—a prediction not supported by experiment. Degradation evidently proceeds gradually, rather than in a step-wise manner, and the micellar size appears to be a function of the degrading process rather than of a pre-existing micellar size in the original native cellulose. This gradual mechanism of cellulose degradation is entirely in harmony with the concept of a secondary structure.

The first action of a degrading agent would be the gradual swelling and dispersion of the non-crystalline material between the II-planes, which would result in a splitting of the II-planes in the direction parallel to the cellulose chains. This process should make more pronounced the lamellae, fibrils, or other convolutions visible under the microscope.

Further degradation would probably result in the formation of II-planes perpendicular to the fibril axis, which, according to Zwicky, should be about 10,000 to 20,000 Å apart. Complete splitting of these perpendicular II-planes should section the fibril into particles similar to those observed by Farr and Eckerson [39] after treatment of cotton with hydrochloric acid.

Upon further degradation, or perhaps simultaneous with the above action, there should be splitting of the $\pi$-planes parallel to the cellulose chains, and this process should give long, fibrous, submicroscopic, colloidal micelles, which, upon further action, should ultimately result in the production of single chains of cellulose.

Simultaneously with the tendency to split along the $\pi$-planes parallel to the cellulose chains, there should be a tendency for the formation of $\pi$-planes in the perpendicular direction. This action should result in a shortening of the cellulose chains; which is in harmony with the well known fact that the molecular weight, or particle weight of cellulose, is variable depending on the degree and nature of the degradation. It may also account for the low molecular weight found by Cramers and Lansing [40] for the cellulose particles isolated by Farr and Eckerson.

This mechanism of cellulose dispersion is also consistent with the theory that crystals dissolve by a sloughing-off of the crystal fragments from the mosaic. Traube and Behren [37] found that crystals dissolve in a saturated solution in the form of particles which may be detected with the ultramicroscope. According to this picture of degradation, micelles do not entirely pre-exist as discrete units in the natural fibre, but are formed during the process of dispersion by a splitting or cleavage along the $\pi$- and II-planes. It is conceivable that different degrading or dispersing agents may act differently; some would tend to split the $\pi$- and II-planes parallel to the cellulose chains, resulting in long fibrous micelles; others would act on the

transverse planes, resulting in shorter chain length and less fibrous micelles. The viscose and cuprammonium processes may be cited as possible examples of reagents specific in their degradation.

*Sorption of Dyes:* Rose [33] has called attention to the relation between dye particle size and the dyeing of cellulose, and to the fact that dyeing of a fibre is greatly affected by its past history.[56] Since the fibres are essentially similar chemically they must be very dissimilar in physical structure, and it is difficult to explain this difference on the basis of a micellar or continuous structure theory. If it is assumed, however, that the width, depth and number of $\pi$-planes per unit of surface is a function of the past history, and that the dye molecules are adsorbed in the $\pi$-crevices, then an explanation is more apparent. Lenker and Smith [34] have shown that cotton does not dye readily unless the radius of the dye particle is less than 17 Å. Although this phenomenon is usually attributed to "pore size," it would not seem unreasonable to assume that "pore size" may be directly associated with $\pi$-crevice size, and that the dyes occupy the crevices.

Morey [35] has shown that long chain fluorescent dyes are aligned parallel to the cellulose chains. It is difficult to account for this parallel alignment entirely on the basis of secondary valence attraction, but if it is assumed that the long dye molecules lie lengthwise in or parallel to the $\pi$-planes, then the alignment of the dye molecules parallel to the cellulose chains is to be expected. Since the principal $\pi$-planes are probably parallel to the (101) planes, and since the (101) planes are the most thickly studded with hydroxyl groups, not only would the geometrical features, but also the secondary valence forces, assist in the parallel alignment of the dye molecules parallel to the $\pi$-planes. Furthermore, as pointed out elsewhere,[41] the (101) planes of the mercerized structure are more thickly studded (about 30%) with hydroxyl groups than the unmercerized, and this in part may account for the increased ability of mercerized fibres to take up dyes.

Space does not permit a discussion of all the properties of cellulose in relation to secondary structure, but, generally speaking, the concept appears to be in agreement with most of the known facts about cellulose.

In concluding, it should be emphasized that there is no direct proof for the existence of a cellulose secondary structure, and the concept is offered at this time merely as a tentative suggestion. It does appear, however, to harmonize to a great extent the existing conflicting theories regarding the fine structure of cellulose, and to be in agreement with most of the known facts about cellulose.

## References

1. Smekal, A. *Zeit. Physik., 55,* 289 (1929).
2. Sisson, W. A. *Tex. Rsch., 5,* 119 (1935).
3. Zwicky, F. *Phys. Rev., 38,* 1772 (1931).
4. *Ibid., 40,* 63 (1932).
5. *Ibid., 43,* 765 (1933).
6. Zwicky, F. *Proc. Nat. Acad. Sci., 15,* 253 (1929).
7. *Ibid., 15,* 816 (1929).
8. *Ibid., 16,* 211 (1930).
9. *Ibid., 17,* 524 (1931).
10. Zwicky, F. *Helv. Phys. Acta., 3,* 269, 466 (1930); *4,* 49 (1931); *6,* 210 (1933).
11. Davey, W. P. "A Study of Crystal Structure and its Applications." McGraw-Hill Book Co. New York, 1934.

12. Smekal, A. *Phys. Z., 34,* 633 (1933).
13. Joffe, A. F. "The Physics of Crystals." McGraw-Hill Book Co., New York, 1928.
14. Goetz, A. *Proc. Nat. Acad. Sci., 16,* 99 (1930).
15. Fuller, M. L. and J. L. Rodda. *Trans. A. I. M. E., Inst. Met. Div., 104,* 116 (1933).
16. Barnes, R. B. *Phys. Rev., 43,* 82 (1933); *44,* 898 (1933).
17. Goetz, A. and R. C. Hergenrother. *Phys. Rev., 40,* 137, 643 (1932).
18. Parratt, L. G. *Phys. Rev., 41,* 553, 561 (1932).
19. Tu, Yaching. *Phys. Rev., 40,* 662 (1932).
20. Allison, S. K. *Phys. Rev., 41,* 1, 688 (1932).
21. Evjen, H. M. *Phys. Rev., 41,* 265 (1932).
22. Straumanis, M. *Z. Physik Chem., B13,* 316 (1931).
23. Straumanis, M. *Z. anorg. chem., 180,* 1 (1929).
24. Smekal, A. G. *Phys. Rev., 43,* 366 (1933); *44,* 308 (1933).
25. Orowan, E. *Z. Physik, 79,* 573 (1932).
26. Steinberger, R. L. *Tex. Rsch., 4,* 207 (1934).
27. Kraemer, E. O. and Lansing, W. D. *Nature, 133,* 870 (1934).
28. Staudinger, H. *Chem. Ztg., 58,* 145 (1934).
29. Buckley, H. E. *Z. Krist., 88,* 381 (1934).
30. *Ibid., 82,* 31 (1932).
31. *Ibid., 82,* 37 (1932).
32. Astbury, W. T. *Trans. Faraday Soc., 29,* 193 (1933).
33. Rose, R. E. *Am. Dye. Rptr. 21,* 51 (1932).
34. Lenker, S. and J. E. Smith. *Ind. Eng. Chem., 27,* 20 (1935).
35. Morey, D. R. *Tex. Rsch., 4,* 491 (1934).
36. Rose, R. E. *Ind. Eng. Chem., 25,* 1265 (1933).
37. Traube, J. and W. V. Behren. *Zeit. phys. Chem., 138,* 85 (1928).
38. Bailey, I. W. and Thomas Kerr. *J. Arnold Arboretum, 16,* 273 (1935).
39. Farr, W. K. and S. H. Eckerson. *Contrib. Boyce Thompson Inst., 6,* 309 (1934).
40. Kraemer, E. O. and W. D. Lansing. Am. Chem. Soc. Div. Cellulose Chem. New York, 1935.
41. Sisson, W. A. *J. Phys. Chem.* In press.

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(*Editorial continued from page 142*)

## Fibre "News" Awaiting Confirmation

UNTIL samples and definite data are available, news reports of a new synthetic cotton developed in Japan may be safely interpreted as a rayon yarn or cut fibre having a rice straw instead of cotton linter or wood pulp base; of a "new" thin, strong and silk-like fabric "made from the common stinging nettle" as a ramie product; and of "Lanital" or "Lanitol," the much publicized synthetic wool yarn with a casein base produced in Italy, as some variation and possible improvement on the casein sutures first used during the World War.

# The Quantitative Determination of Stiffness in Individual Yarns

By DR. IRVING J. SAXL *

## Summary

IN view of the importance of the exact knowledge of stiffness in individual yarns and yarn combinations, a method has been developed for measuring these characteristics quantitatively. It consists essentially in determining the force necessary to bend a piece of yarn, held at one end, through various angles. For convenience in the application of the force, the yarn is formed into a U-bend, the load being applied at the center of the U. The bending angle is variable by means of a turning device. The instrument is used in conjunction with an analytical balance.

The method described lends itself to a great many different applications. Among others, the load-versus-deflection characteristics for various types of yarn have been determined. The influence of the number of filaments and proper sizing upon the stiffness is shown, as is the hysteresis effect. The method lends itself to the determination of the modulus of elasticity.

## Introduction

One of the most characteristic qualities of yarns and yarn products is their stiffness and softness respectively. This determines the "handle and feel" to a large extent. In addition, other characteristics, such as the influence of size upon a yarn, are indicated by a reliable knowledge of the stiffness relations.

It has been tried repeatedly to ascertain the stiffness of filamentous and sheet-like materials by various methods. The simplest is the qualitative examination in the woven cloth by the sense of touch. Other subjective methods are based upon the examination of a loop or of a free end of material. For instance, in the Schiefer apparatus [1] used by the Bureau of Standards, qualitative results are obtained by bending a piece of cloth or paper a given angle against the torsional resistance of a spring. It is essentially a delicate torsion folding device.

Another instrument for measuring stiffness, which is particularly applicable to sheet products like paper, is the Gurley Stiffness Tester.[2] The stiffness of the specimen is measured by clamping a prepared sample in a movable arm and dragging the sheet over the top of a weighted pointer until the bending of the sheet releases the pointer. The amount of deflection of the pointer is read on a scale and constitutes a relative measure of stiffness.

A method has been described by Pierce,[3] and further developed by James d'A. Clark,[4] which consists of inserting a strip of paper (or any other sheet) between two rolls, one of which may be turned. The line of

* Consulting Physicist. Formerly Director, Research and Development, Waypoyset Mfg. Co.

contact of the rolls is parallel to the axis of rotation of each roll. The clamping attachment is rotatable relative to a circular scale. The length of the overhanging strip is adjusted in such a manner that the strip just falls over in both directions of rotation when the framework is turned back and forth through a right angle. The overhanging length may then be measured on a millimeter rule. For details of the method, reference is made to d'A. Clark's original paper.

The above and other methods for the determination of stiffness, referred to in the bibliography, concern themselves almost exclusively with more or less qualitative means of estimation and are not applicable directly to single yarns. For making absolute determination quantitatively and for individual yarns, a new method has been developed which is discussed in the following paragraphs.

## The Instrument

The following equipment has been designed for making stiffness measurements. Fig. 1 is a photograph of the apparatus while Fig. 2 shows the working principle involved.

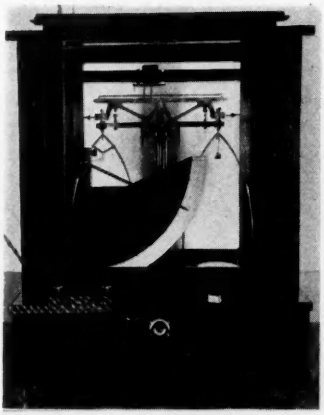

FIG. 1. Photograph of the Stiffness Tester.

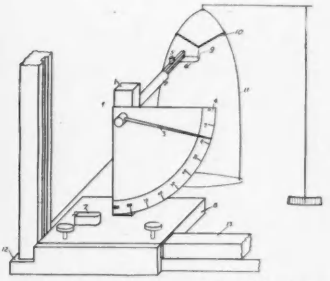

FIG. 2. Diagram of the Working Principle.

On a pivot, 1, is attached a rotatable horizontal rod, 2. This rod has a pointer, 3, on its front end which plays over a graduated scale, 4.

At the other end of the horizontal rod there is a clamp, 5, which holds a loop of yarn, 6, in such a manner that the origin of said loop coincides with the axis of the horizontal rod.

The form for the loop is a small jig, 7, which is inserted between the loop and the clamp, 5, around which the loop is drawn while the yarn is tightly clamped. This jig, 7, is shown lying on the base plate, 8. After the loop is formed, the jig is removed.

The loop, 6, is inserted in the fine wire hook, 9. This hook is held by a V-formed suspension, 10, which fits upon the frame of the bow pan, 11,

of a sensitive, analytical balance. By turning the horizontal rod, 2, in a clockwise direction, the loop is pressed against the hook. By placing the rider of the balance properly, the force can be measured that is necessary to bring the balance (and thus the yarn) back to zero position.

For securing the same position of the stiffness tester, its base is held in position in the balance chamber by the L piece, 12, which fits outside around the scale cabinet. Inasmuch as the base plate, 8, interferes with the closing of the front cover of the balance, the block, 13, is inserted to eliminate any draft from the interior of the scale cabinet. In this manner, the front cover of the scale closes tightly and the weighings can be carried on in the customary manner.

By determining the proper weight necessary to have the scale read zero for different angles of deflection, the load-versus-deflection characteristics of a yarn can be determined.

While the chain weight yarn tester, previously described * gives means of determining the *longitudinal* characteristics of the yarn in terms of the dynamic characteristic, the stiffness tester referred to above makes possible the study of the *transversal* characteristics of the yarn, its modulus of elasticity and many more. Also strips of cloth or narrow sheets may be investigated in an analogous manner.

## Discussion of Results

Fig. 3 shows a load-versus-deflection curve for different types of yarn. A and B are viscose-type yarns, while C is an acetate-type yarn. It will be realized from this quantitatively how more load is necessary to bend viscose-type yarn than an acetate-type yarn to achieve equal deformation. In an analogous manner, the softness imparted to yarn by an increase in the number of filaments can be measured as well as the influence of chemical

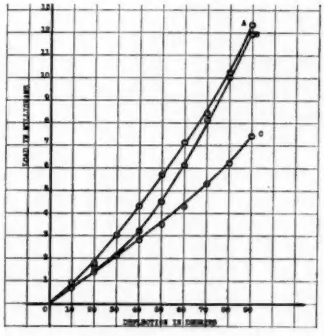


Fig. 3. Difference in the Load-Deflection Characteristic for Different Yarns.

A. 150 Denier 40 Filament Viscose Type
B. 200 Denier 75 Filament Viscose Type
C. 150 Denier 50 Filament Acetate Type

* Irving J. Saxl. The Dynamic Properties of Filamentous Materials. *Tex. Rsch.*, Oct. 1935, P. 519–36.

composition, physical treatment, and denier upon softness, the connections between twist and stiffness, to mention but a few. The change in the behavior for various yarn constructions can be followed closely and interpreted easily by use of the dynamic characteristic and by stiffness measurements.

Also the rôle played by the denier of the single filament will be realized. It can be seen that even a 200 denier, 75 filament yarn (A) can be softer than a 150 denier, 40 filament yarn (B) of the same type, due to the fact that the denier of the individual filament is $200/75 = 2.67$ for yarn (B) while the individual filament of yarn (A) is coarser, showing $150/40 = 3.75$ denier.

It should be noted that the ascending and descending parts of the load-versus-deflection curve do not fall on the same line (see Fig. 4), indicating

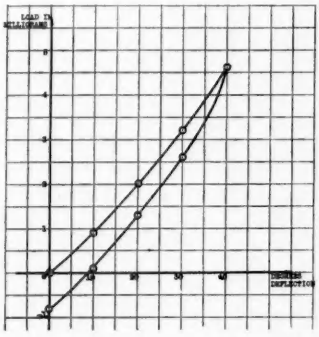

FIG. 4. Hysteresis for 200 Denier 80/6 Viscose-Type Yarn.

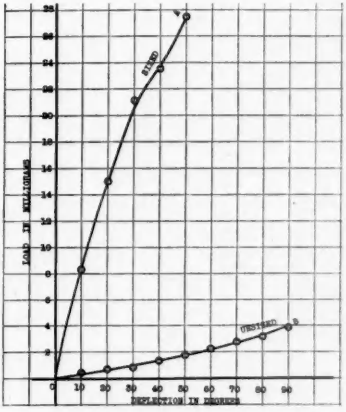


FIG. 5. Stiffness of the Same Acetate-Type Yarn Before and After Sizing.

that work must be expended to overcome the changes of internal structure in the yarn brought about by bending it. This opens a possibility of investigating the relation of area circumscribed by the hysteresis loop, to the work done in deforming the yarn.

It will be seen from Fig. 5 that the slopes of the ascending and descending parts of the curve are different, and that, in addition, negatively directed force is necessary to return the yarn to the original zero position, showing that it was plastically deformed.

In addition to examining the yarn proper, it is possible in this manner to determine the flexural characteristics of the combination between yarn and other materials such as size. Fig. 5 shows the load-versus-deflection characteristic of the same acetate-type yarn, sized and unsized. It will be readily seen that the stiffness imparted to yarn by the size can be ascertained in this manner quantitatively, and that it is therefore possible to determine the stiffness of the yarn as a function of the size, an important factor for predicting how the sized yarn will behave during the weaving operations.

## References

1. H. F. Schiefer. *B. S. J. Rsch.*, May, 1935.
2. (Anon.) R. D. Gurley. "Stiffness Tester." *Paper Trade J.*, Dec 20, 1934.
3. F. T. Pierce. "Influence of Humidity on the Elastic Properties of Starch Film." *J. T. I.*, June, 1928, P. T237.
4. James d'A. Clark. "Determining the Rigidity, Stiffness and Softness of Paper." *Paper Trade J.*, Mar. 28, 1935, P. 41–4.
5. A. C. Bragg. "Stiffness Tester for Boards." *Paper*, Nov. 20, 1924.
6. E. H. Riesenfelt and T. Hamberger. "Testing the Stiffness of Paper." *Papierfabr.*, Nov. 17, 1930.
7. H. Micoud. *Le papier*, 251–8 (1931).
8. R. I. Martin and G. R. R. Bray. "Flexibility or Stiffness Tests Using the Flexometer." *World's Paper Trade Rev.*, Dec. 29, 1933.
9. C. C. Heritage, E. R. Schafer and L. A. Carpenter. "The Measurement of the Strength and Stiffness of Fibre Boards." *Can. Pulp Paper*, Oct. 31, 1929.
10. S. F. Smith. "The Rigidity of Box Board." *World's Paper Trade Rev.*, Feb. 1, 1935.
11. F. W. Adams and J. Bellows. "The Value of a Paper Stiffness Test." *Tech. Assoc. Papers*, 1935. (G. S. Witham, Jr., U. S. Patent, 1,385,164, Nov. 1921.)
12. W. H. Stuart. "Paper Stiffness Tester." *Paper Trade J.*, Nov. 19, 1931.
13. H. Schultz and W. Ewald. "The Stiffness of Paper and Its Measurements." *Papierfabr.*, Nov. 29, 1925.
14. W. Ewald. "New Stiffness Tester for Paper." *Papierfabr.*, May 15, 1927.
15. E. C. Carter. "The Carter Paper Stiffness Tester." *Paper Trade J.*, Oct. 8, 1931.
16. Anon. *Paper Trade J.*, Nov. 30, 1933.

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(*Editorial continued from page 142*)

# Turbulence in Wool Dyeing

COMMENTING upon the discovery of British chemists that the introduction of turbulence in wool dyeing makes possible good penetration at temperatures well below the boil, A. H. Pettinger * finds "it hard to foresee how turbulence is going to be maintained and controlled in the average dyebath. As long as temperature was the important factor in dyeing, the operator was on fairly safe ground and he had but to use a thermometer in order to find out how things stood in the vat. Then again, pH was measurable by relatively simple methods. A small portion of his liquor was taken out and tested with indicators in a tube. With turbulence, however, we are at once in difficulties, for no method of control or measurement seems possible at the moment. The dyer will, however, be called upon to control the pressure inside his vat which will presumably be totally enclosed. The general effect of this development to the dyeing fraternity, as with the other recent technical advances will be to make him a physicist rather than a chemist."

* *Am. Dye. Rptr.*, July 1, 1935.

# Micro-Analysis of Textile Fibres

## Part V. Observations on the Structure of Kemp

By G. GORDON OSBORNE *

*Fellow of the Textile Foundation*

### Summary

*The recent work on the actual structure of kemp has proven the following: First, that there is a definite scale formation on the surface of the fibre completely encasing it. In all respects this is similar to wool. In themselves, however, the scales are smoother in surface and less jagged in edge; they are less prominent in their projection from the fibre, both in length and angle; nor do they overlap to the extent common in wool.*

*Second, in cross-section the fibre is strikingly different. Scale and outer casing are the same; the interior of the fibre, however, is just the reverse of normal wool. In kemp the cortical layer is extremely small, whereas in wool it forms the major portion of the fibre. In both, this layer appears as a homogeneous mass, though in reality it is formed by myriads of tightly-packed and closely-cemented spindle cells. In some wools a fine medulla forms a core through the centre of the cortex.*

*Third, it is this medulla that comprises the major part of, and is the distinguishing aspect of a kemp fibre. It is cellular in composition, the cells being spaced without break throughout the fibre. They are irregular in size and outline and are arranged in similar order to the cells in a honey-comb. This medulla in true kemp is the product of a special group of cells in the root (is annular in growth) and therefore can scarcely be considered an abnormality.*

*The much greater reflection from kemp (due to the air filled medulla) is the cause of the difference observed after dyeing. In reality, however, it has been shown by removing the air that kemp and wool are almost equally dyed; penetration and affinity being very similar.*

### Introduction

EARLY workers (Bowman,[4] Matthew [3]) regarded kemp as a malformation of normal wool, differing from wool through a fused surface, lack of projecting scales and ivory opaque appearance. According to them, kemps resist dyeing; occur in particular parts of the fleece-legs; are short in length; and a sign of want of trueness in breeding.

* Mr. Osborne worked under the direction of Prof. E. R. Schwarz, Textile Laboratory, Massachusetts Institute of Technology, Cambridge, Mass.

Priestman [10] showed that the brightness or silveriness of kemp by reflected light, and its density or opacity by transmitted light, were due to the air enclosed in the fibre. Removal of the air makes the fibre transparent. He too, regarded the fibre as a malformation or faulty wool fibre.

Perhaps the best description of the origin of kemp is given by Roberts.[8] He points out that most mammals, including the primitive varieties of sheep, have two coats—an outer coat of protective hair and an inner warmth-retaining one of fine hair. The reasons for holding kemp in the modern fleece to be a remnant of the primitive outer hair follow:

> (1) There is a great structural similarity between kemp and primitive hair.
> (2) Sheep can be found whose fleece represents an intermediate condition between the two coats of a primitive sheep and a kempy sheep.
> (3) In many primitive varieties the outer coat is pigmented, the inner one white. Exactly the same situation occurs in many kempy fleeces, the wool being pure white, the kemps red, yellow, brown, or black.
> (4) The experiments conducted by Duerden [6] on pure-strain merinos, where the birth coat of the lamb (entire body, head, limbs and sides) is provided with long, straight, kempy hairs; a striking confirmation that the merino's ancestors were two coated.

Thus it would seem on the whole that kemp, notwithstanding the popular ideas that it is a dead fibre, non-cellular and malformed, is in the main a retention of an ancestral hereditary character not yet entirely eliminated by breeding, but much more intensely influenced by this than by any environmental factor.

## Technique

Kemp is structurally the simplest of the wool fibres. Its dimensions, large when compared to merino wool, allow for relatively easy manipulation. From the viewpoint of the breeder or practical manufacturer such a fibre is not a subject for detailed investigation but for elimination. Nevertheless, as in the vegetable fibres, suitable techniques must be evolved before study on the more complicated and more valuable fibres can be undertaken. Without an understanding of the techniques involved, the task would be impossible. Kemp is the fibre that has allowed experimentation with the techniques reported in previous papers. By its use an understanding of the individuality and excentricities inherent in each procedure has been possible.

## Sectioning

The following work is based on a sample of Welsh mountain wool, chosen on account of its high kemp content. There are three distinct types of fibre in this sample; Figs. 1, 2 and 3 illustrate the surface appearance of the three types, while Fig. 4 shows the appearance of ordinary wool.

The heaviest, coarsest fibre appears as a long, white tube. Its length is between 2.0 and 6.5 cm. and its large diameter approximately 0.15 mm.

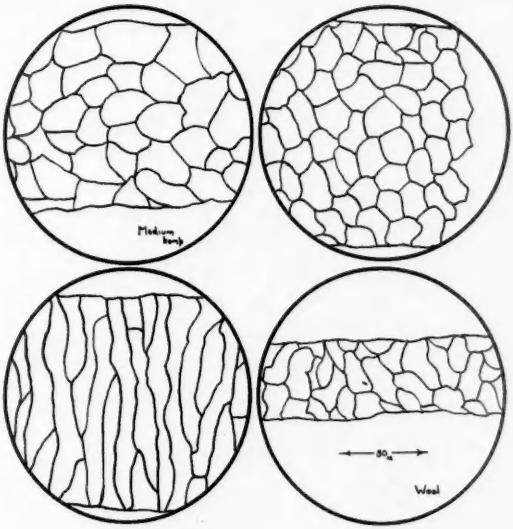


FIG. 1, upper left. FIG. 2, upper right.
FIG. 3, lower left. FIG. 4, lower right.

The tube appears to be of cylindrical form, but injuries and imperfections appear as bends or joints across the fibre. There is some crimp, about 9 per inch, but no curl; the fibres are generally straight or only slightly bent. The surface is smooth and lustrous, and the fibre itself is soft, although the outer skin is tough. Under a low-power microscope the fibre is opaque; no internal structure such as a central channel is apparent, nor is there evidence of external markings. The inside of the fibre (as seen when split) appears to be composed of a spongy or rubbery material of a loose and resilient nature. (Fig. 5.) During cutting this inner composition is

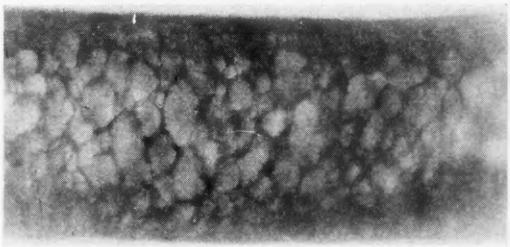

FIG. 5.

not substantial enough to offer a firm surface to the stroke and tends to be pushed out of its normal position; so that, when the split is completed the inner portion is not left as a smooth plane, as are the outer walls or skin, but as a spongy mass of bunchy ridges and hollows. Also during cutting the fibre tends to be compressed out of its normal cylindrical form, and returns only partially when the cutting element is removed.

Fig. 6 is a micrograph of a split section. This shows the beginning of the cut and the distortion; the walls or outer skin *W*, and the inside

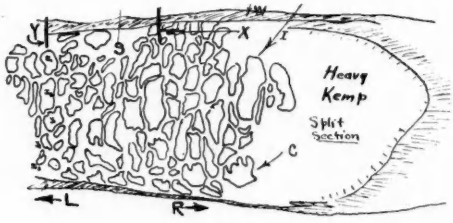


FIG. 6.

composition *I*. It is the inner composition which is the most interesting. This appears to be a series of cells *C* bound together or surrounded by a spongy material *S*. The cells show up clearly defined under the microscope (Leitz Ultropak) and appear as tightly covered drum heads, their relation and general arrangement are approximately as boulders in a stone wall. The other element *S* is less clear, but appears spongy and cloudy; many times looking like soft, loose snow. It occupies the space between the cells, and is subject to a full range of shades and shadows. The maximum long length of the cell is approximately 65 microns, the minimum 7 microns, and the average 22½ microns. The short length (width) dimensions are 20 microns maximum, 2 microns minimum, and 12 microns average. It will be noted that the length of the majority of cells lies perpendicular to the fibre axis, and that the distance between cells is greater in this direction.

Two cross-sections were taken of the split fibre shown in Fig. 6. These are illustrated in Fig. 7. In A the split fibre was cut at approximately point *X* (Fig. 6) and then viewed in the direction *R*. The cross-cut was at right angles to the length of the fibre axis. In B the cut was at ap-

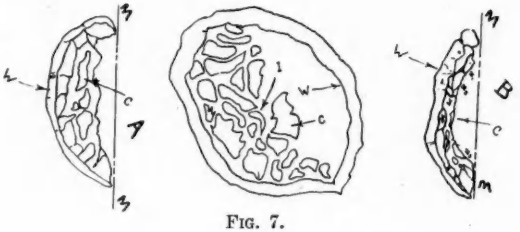


FIG. 7.

proximately point *Y* and the section viewed in the direction of *L*. These split cross-sections resemble troughs or "rain-gutters" in which the outer skin plays the part of the material "gutter" and the inner composition the liquid which it carries. Thus in Fig. 7 the outer skin *W* supports or carries the inner composition—cells and the spongy composition *C*.

It will be noted here that the inner composition does not completely "fill" the space provided by the outer wall; *i.e.*, that it is not up to the level of the lines *M–M*. This is to be expected, for during the splitting under the binocular stereoscopic microscope it was observed that there was a disarrangement of the inner composition into ridges and furrows, and that there was no appearance of a level cut and consequent smooth plane.

A word of explanation is needed to relate the different parts of Figs. 6 and 7. It would appear from the latter that there was not a compact layer of cells extending throughout the section. That this is the normal condition is to be seen from Figs. 8 and 9. However, the rather delicate

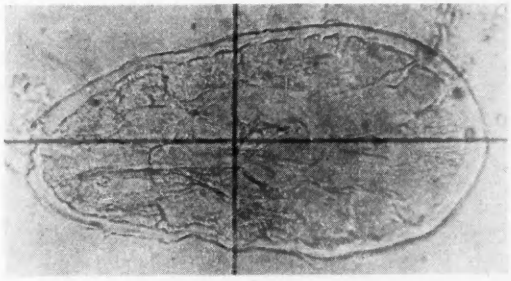

FIG. 8.

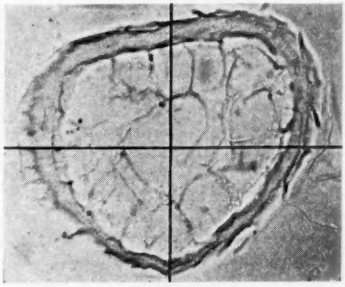

FIG. 9.

sections of Fig. 7 may have been damaged with a resulting loss of cells, in splitting or cross-sectioning.

The upper part of Fig. 10 illustrates the second type of fibre, a kemp, but of decidedly different physical characteristics. These fibres are longer

and thinner (Fig. 12 compared with Fig. 11); their length ranging up to 20 cm. and their approximate diameter is .075 mm. There is no curl or crimp, but the long fibres are wavy and tend to loop around themselves. The fibre itself is smoother and less lustrous. Under a low-power microscope there is definite evidence of a central medulla. This shows up as a thick, white, opaque channel, bounded by the outer skin which appears decidedly thinner and transparent. In this case, as in that of the heavier kemp, the cell structure can be observed at low power (20 x diameter) with proper lighting, but it is more difficult to discern. The greatest apparent difference between the two kemps is in the color and diameter, the heavier kemp being decidedly whiter and many times thicker.

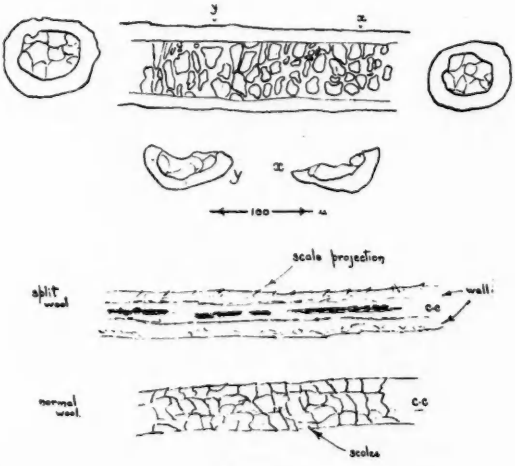


FIG. 10.

Fig. 10 shows two cross-sections cut from the fibre shown in the center of the figure. As compared with the heavier kemp, these sections show a much thicker wall and less definite internal cell structure, besides fewer cells per unit area and less spongy surrounding medium. Under the microscope the internal structure is vague; the cells, or division lines which divide up this internal area, are not clear-cut. Moreover the spacing and shape of the cells is not similar to that shown in any split section; the cells being in closer contact and being smoother in outline and larger in area.

It is seen from the split section of Fig. 10 that the outer wall is thicker than that of the heavy kemp, this checking with the cross-sections. The cells themselves are more uniform in shape and size; their arrangement is similar, again resembling a stone wall. The size of the cells is much smaller, the average length being 12½ microns, the average width 8 microns. Again, the length of the cells tends to lie at right angles to the fibre axis while the shorter distance between cells is along this axis.

Two cross-sections were made from the split section of Fig. 10, at approximately points *x* and *y*. These split cross-sections are shown. Here again the thick outer wall is seen, also the large divisions or cells in the inner structure. There has apparently been less change from the normal due to cutting, than in the heavier kemp. This was to be expected, as in handling and cutting it is apparent that the heavier kemp is the softer, and its inner composition more loose and resilient. Such resistance to change in this medium-sized kemp may be due to the relatively larger cells which

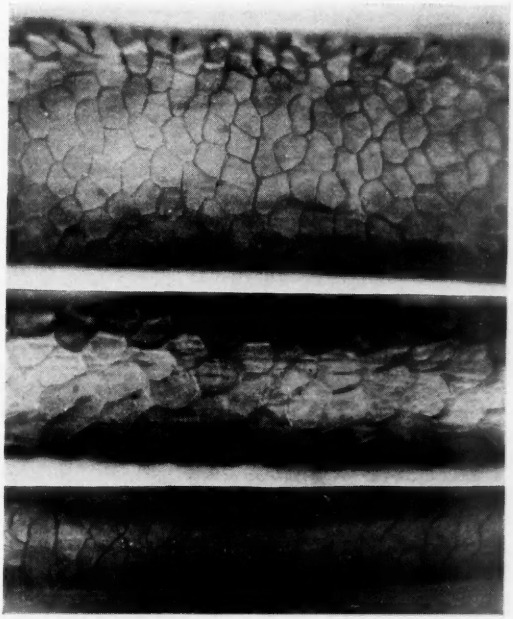

FIG. 11. Heavy kemp (top). FIG. 12. Medium kemp (centre). FIG. 13. Wool (bottom).

offer a firmer structure to disturbing forces. It may also be due to the greater area taken by these cells, at the expense of the spongy surrounding material, which reduces the loose and resilient nature of the inner composition.

The third fibre composing the sample is the actual wool itself. This is a typical coarse wool fibre, about 20 cm. long. There is some curl and crimp, while the fibre is springy and tends to curl and loop about itself. Under low power (20 x diameter) the fibre appears smooth, transparent, and lustrous; there is no evidence of internal or external formations.

The lower part of Fig. 10 shows such a fibre split open by the same technique as employed for the kemps. The major note of interest is that there is not the slightest evidence of similar cell structure. The central channel is clear and carries dark intermittent pigment bars; the side walls are approximately the same width as the channel, and the scale structure from the bottom and sides of the fibre is seen beneath the cut plane of the walls. These appear as faint broken lines and trace the outline of the scales. On the side of the fibre these scale endings are seen as slight pointed projections.

A micrograph of the same fibre, but at an undisturbed place, is also shown in this figure. It is included to show the scale structure and the normal appearance of the wool. Under the microscope, as shown, the scales are easily visible, also the central channel outline is seen in dim form. The scales completely surround and cover the fibre and are in great contrast to the kemps where no scale formation is seen under usual conditions.

Many of the actual wool fibres show no medulla. The one illustrated above is thus in closer relationship to the kemps. Both, nevertheless, do have an internal cellular composition. However, these cells are packed in so densely and are so small as to be non resolvable in their normal condition. That they do exist and that their spindle shape is definite can be seen when a fibre is disintegrated chemically or bacteriologically.[1, 2]

## Casts

Casts were made of the three types of fibre in the wool sample. (Figs. 11, 12, 13.) There has been considerable speculation as to the exterior of kemp fibres. In wool, as is common knowledge, the scaly exterior easily visible with a microscope is one of its salient and most valuable characteristics. With kemp such is not the case. To the naked eye the fibre appears extremely smooth with no evidence of any structure whatsoever. Under a low-power microscope no outside formation is evident, although with careful examination internal structure is visible. With high magnification by transmitted light, the internal composition is so prominent as to effectively hide all surface irregularities. In fact, the surface under all conditions appears as a smooth, tough, amorphus skin; a mere casing covering the inside.

That such a speculation is erroneous is immediately realized upon inspecting the illustrations of Figs. 11 and 12. Kemp has a distinct scale surface. In the case of the heavy kemp this appears to be of two varieties (Figs. 2 and 3). In the medium kemp (Fig. 1), only one was observed, and this is more similar in formation to that of true wool (Figs. 4 and 13).

Not only do such casts prove the fact of an exterior scale, but from them certain quantitative results can be obtained. Such data as area and dimensions of scale, scales per unit length and area, and by focusing on an unbroken side, the scale thickness and angle, amount, and direction of projection can be measured.

Some difficulties were encountered when making casts of the "heavy" kemp fibres. In the first place, these fibres possess such a decided crimp that it is impossible to have them in intimate contact with the slide throughout the length moulded. Consequently, the moulding medium flows completely around the fibre, wherever there is a rise or swell. When hardened, this forms a tough casing through which it is almost impossible to remove the fibre.

Some other means than straight withdrawal is therefore necessary, and the following has proven to be satisfactory: The entire mount is placed face downwards under the binocular stereoscopic microscope (Fig. 14). With a specially designed scalpel an incision is made in the embedding medium above the fibre and along its length. The depth of the incision will vary with the contour of the kemp, but should be so controlled as never quite to touch the fibre itself. Thus the fibre is left undamaged with only a very thin layer of embedding medium covering it. (Sometimes with very heavy specimens, instead of a single incision, a thin strip of the medium must be removed.) Now by carefully cutting along one end of the kemp, and teasing this end up with a fine needle so it can be held in tweezers, a gentle pull is sufficient to remove the fibre and leave the cast undamaged. If the fibre breaks when being pulled from the cast, it is better to start again from the other end, as this leaves the center of the cast unspoiled.

FIG. 14.

However, if both ends break off, the fibre can be started again in the middle of the cast by carefully cutting along both sides of the broken end and then lifting it to the surface by wedging a fine needle between the cast itself and the lower side of the fibre. The larger the specimen, the deeper the embedding, and the tougher the medium, the more difficult fibre removal becomes.

Secondly, with such a large fibre, care must be taken to see that the embedding medium, when hardened, adequately covers the fibre. There is a tendency for some of the mediums used to evaporate so as to leave only a very thin coating over the fibre, which projects far above the evaporated medium. Removal of such a fibre without spoiling the cast is impossible. There is no support and no body around the major and most important part of the cast, and the walls of the cast itself are too thin to withstand any but the smallest strain.

Thirdly, and this difficulty lies in the kemp itself, there is a tendency for the medium, when solidifying, to exert such a compressive force as to

crush the fibre well out of its normal contour. This not only makes fibre removal more difficult, but tends to destroy the surface details on the specimen so that the impression obtained is not a true picture of normal conditions. To minimize this difficulty, the entire mount may be removed from the slide as soon as possible after pouring, and the fibre taken from the cast as soon as it is firm enough to hold its impression.

## Polarized Light

The use of polarized light greatly facilitates the investigation of the internal structural detail of kemps (Fig. 15). The following observations relate to balsam mounts of "heavy" kemp fibres. A petrographic microscope was used with the nicols crossed, the cross-hairs parallel to the planes of the nicols, and 10x ocular and 8 mm. objective.

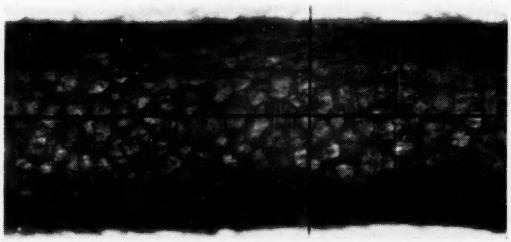

FIG. 15.

The outer skin of the fibre is brightly lighted and highly irridescent; very similar in appearance to that of a dry ramie fibre under the same conditions. Upon rotation of the stage this outer covering becomes extinct when parallel with the cross hairs (planes of the nicols) and reaches its maximum brilliance at an angle of 45° to them. No detail, structural or otherwise, can be observed here. When sharply focussed, this skin is many times thinner than the inner core, the proportions being approximately 1 to 20 (skin = 12 microns; core =250 microns).

The core of the fibre appears very distinctly. In color it is a medium light-brown. The cells and their surrounding medium are very clear, the cell outlines being well defined by clear black lines. Changing the focus will bring into minute detail each part of the sloping sides of the cylindrical core. The best results are observed, however, when the focus is set up at the top where the widest field and undistorted cells are obtained. Once again, the arrangement and resemblance of the cells and their surrounding medium suggests cobble or stone wall construction, or the rough bark covering of a tree. The illumination and color of this central core appears to be unaffected by rotating the specimen. A magnified section of the cell structure is shown in Fig. 16.

Longitudinal sections of the same fibre, as described above, were made, mounted in balsam, and viewed under similar conditions. Care was taken to include in the mount, alongside the split fibre, the portion which was

cut from it; both sections being arranged so that their cut planes were exposed for inspection. The appearance of the cut section is not as definite as that of the normal fibre. In color it is a greyish white. The cell

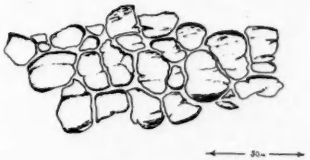

FIG. 16.

outlines are not so clear, and appear as dark sketchy lines. Fig. 17 is an illustration of such a section. It will be noticed, moreover, that some of these cells are shaded; this is to represent a difference in color (*i.e.*, these shaded cells are brown), about the same color as those in the undisturbed fibre. Such cells are generally only a small part of those contained in the split section, and more will be said of them later. Rotating the split sections shows decided effects; the specimen is most brightly lighted at an

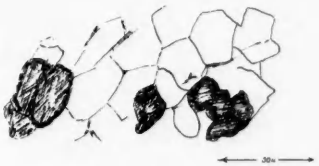

FIG. 17.

angle of 45° to the planes of the nicols, while, when parallel to these planes, the section becomes extinct. By extinction is meant that the cell walls (the body of the specimen), the majority of which are not aligned with the fibre, do not disappear; they are seen as brightly shining lines, which, now that

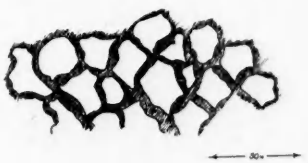

FIG. 18.

the body of the fibre is black, very clearly outline the cell itself. They resemble ice-coated, open-mesh wire. This effect is similar to that illustrated in Fig. 18. When the fibre is at an angle of 45° these lines are

much darker, but approximately the same dimensions. In all positions there is some evidence of the "saucer" shaping of these cell boundaries, as they curve under the individual cells to completely surround them.

Any imperfections in the normal fibre (a bend, break, sharp twist, or partial rupture) is clearly evident as a clear white projection into the light brown core. The cell outline and structural effects, now colorless, are just as definite, and it is also possible to see how the individual cells have been distorted.

Fig. 18 is a micrograph in which an attempt has been made to show a single layer of individual cells uninfluenced by other surrounding composition. This sketch is made from the thinnest part of the shaving (wedge) sliced from the split section shown in Fig. 17. Below the cells shown there is no further inner material; merely the inside of the outer skin. The cells are very clearly outlined and their surrounding material (which previously had been thought of as a resilient, spongy substance) appears fairly definitely to be only cell wall or membrane. Thus the very spongy, resilient aspect of the inner composition is probably due to the splitting of the fibre, which, as the blade passes down through the center of the cells, tears them apart (one from another, not from the outer wall) and leaves them bunched and distorted. This inner surrounding material, previously regarded as being distinct from the cells, may now be thought of as a mass of cut or ruptured cells, compressed and rolled-up by the action of the knife.

The tip of the fibre is composed entirely of the outer wall material, as is also the root, the very end of which is serrated, minute projections extending from it in the shape of a fan. Back of the tip and root is an intermittent length of cell structure, until the unbroken inner medulla of the cells starts as a thin, narrow cone. The cut-ends of the fibre show outer wall and inner cell structure, but the color and reactions of these portions are similar to those of the imperfections. This appearance is due to permeated cells but does not run far; close to the cut-end the normal light-brown color of the undistrubed inner composition starts.

Taking the same portion of the fibre as shown in Fig. 18, the thinnest part of the wedge-cut shaving, and inserting the "first order red" retardation plate the following changes are noted: The specimen at an angle of 45° to the nicols' planes turns yellow orange, while the cell walls at right angles to the specimen axis turn red-purple. Rotation to the left (counter-clockwise), until the specimen is parallel with the cross-hair, extinguishes the specimen body (the body and background being both the same color and shade—magenta), leaving the cell walls that run upward from right to left, purple, and those running from left to right, orange. Further rotation to the left changes the fibre to blue-purple against the same magenta background, the cross (right angle to axis) cell walls being golden. The ¼-wave plate produces no color change in the specimen.

Following the same procedure on the normal fibre, first using the "first order red" plate, and having the fibre parallel to the cross-hair, the insertion of the plate barely changes the light brown color of the cells; however, when the fibre is rotated 45° on either side of the first position certain changes are noted. Rotation to the left gives a purplish cast to the brown cell; to the right, the brown becomes yellower. Thus the appearance of the untouched cells, viewed without the plate, is deceiving; for rotation, instead of having no effect upon the fibre as previously surmised,

now shows a tendency to parallel extinction (in the same direction) as the other sections.

In an effort to find out the relationships existing in the cell walls themselves, the following procedure was adopted: A split section was selected in which the cell wall outlines were clearly seen. This was placed upon the stage of the microscope. The "first order red" retardation plate was inserted and the wall outlines brought into sharp focus. As the specimen was rotated, producing constant color changes, a watch was kept to see when any portion of the cell wall extinguished—*i.e.*, matched the color of the background. At this point the cell wall, the portion extinguished, and the cross-hairs were recorded. Several such examples are illustrated in Fig. 19; it will be noted that extinction comes when the cell

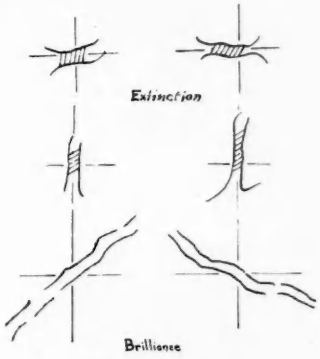


FIG. 19.

wall is parallel, or nearly parallel, to the cross-hairs. Thus the wall reacts in the same manner as the fibre itself. A further likeness to the fibre, and a further check on parallel extinction, is shown by the position of the cell walls in relation to the nicols' planes when they reach their position of maximum brilliance. Thus in both illustrations pertaining to this (Fig. 19) the fibre is at an angle of approximately 45° with the cross-hairs.

Referring again to the individual cells; it has been stated that the untouched cells appear brown in polarized light, while damaged or cut cells appear white. The reactions noted above have all been from balsam mounts of the fibre. From this a possible explanation of the changes in color may be drawn. The light-brown colored cells are those which are whole, allowing the penetration of no outside medium. They are tight; each one complete in itself. The others, which show white, are those which have been penetrated by an outside medium—in this case balsam. The balsam enters directly into the cut or badly ruptured cells (as shown by the white color of the split sections, and butts and imperfections of the normal fibre) immediately after mounting. When the cells are not badly damaged the infiltration of the balsam takes longer. It has been noticed that in split sections, and especially in mounts where the inside of the

fibre has been removed by scraping, many seemingly complete (undamaged) cells, at first appearing light brown, after a time lose this color and turn white. The scraped-out inner composition changes in a few hours, due to the more severe action, while the cells in the split sections sometimes will continue to change for several days. Here the penetration of the balsam may be due to leakage through some very small opening in the cell, or through absorption. No change, however, is noticed in the normal fibre, either at the butt or about the imperfections; the same cells apparently remain unchanged in color and appearance for some time. Thus it would seem that the normal cells were completely tight, tend to remain so, and do not absorb the balsam.

## Qualitative Data

Certain qualitative measurements were made on heavy kemp sections, both cut and uncut. The mean of 15 measurements gives the results shown in Table I.

TABLE I

| | Split sections | Normal sections |
|---|---|---|
| Cell circumference in microns .... | 66.5 microns | 53.9 microns |
| Cell area in square microns ..... | 260.6 sq. microns | 215.5 sq. microns |
| Percent area of cell to circle of equal circumference ..... | 73.1% | 84.6% |
| Cell length in microns ..... | 17.4 microns | 16.5 microns |
| Cell width in microns ..... | 12.7 microns | 11.4 microns |
| Area taken by cell walls in section —% ..... | 34.2% | 21.7% |
| Area taken by cells in section—% | 65.8% | 78.3% |
| Cell wall thickness—all directions.. | 2.6–3.1 microns | 1.9–2.0 microns |

## Theory

Kemp is a fibre which contributes detrimentally to the value of wool. Its cause or origin has been much debated. Earlier writers [3, 4] on the subject regarded kemp as a malformation of normal wool. More recently [5, 6] it has been shown to be a remnant of the outer, coarse, hairy coat of the primitive sheep, and that it is much more an inherited factor than one influenced by environmental conditions.[7]

The present study has been devoted to an investigation of the interior and exterior physical properties of the fibre. Externally, although seemingly unlike and unrelated to wool, there is a close resemblance. Casts show a definite scale structure which completely covers the outside of the fibre. This is not visible, even with the highest magnifications, as the dense and prominent inner composition effectively obliterates the outside detail. High magnification on the outside edge of the wall in a longitudinally-split section, moreover, shows that the scale is attached to the casing of the fibre in a manner similar to wool scale and cuticle.

These scales on kemp fibres tend to be smoother than those on wool which have a slightly jagged edge. They are less prominent in their projection from the fibre wall, both in length and angle, nor do they overlap to the extent common in wool. There appears to be no difference in the cuticle of the two fibres.

The middle or cortical layer is very different. In kemp it is thin and composes but a small part of the fibre,* except at the root and tip, which are solely of this material with a covering of cuticle. In wool the body of the fibre is the cortex, which, although appearing as a homogeneous mass, is in reality formed by myriads of tightly-packed and closely-cemented, spindle-shaped cells. In some wool fibres a small medulla forms a core through the center of the cortex.

The medulla in kemp forms the major portion of the fibre. It is cellular in composition. The cells are closely packed together and extend in this manner without break throughout the fibre. They are irregular in size and outline and are arranged in the fibre like stones in a stone wall or the cells in a honey-comb. Inspection with transmitted light shows the medulla as a black core; with reflected light as an opaque, shiny, white rod. This is caused by the inclusion of air or gas in the cells. The presence of this may be shown by immersing a punctured fibre in liquid; on compression, small bubbles can be seen leaving the puncture hole. Removal and drying permit the cells to take in air.

It is this large, air-filled medulla which characterizes kemps and causes the chief difficulty encountered in wool manufacture. This explains the inability of kemp to appear like wool when dyed. The reaction has been well illustrated by Hirst and King [8] in their analogy of a solid glass rod and one filled with glass particles. The wool fibre is represented by the solid rod of glass; kemp, by the glass tube filled with glass particles. Even

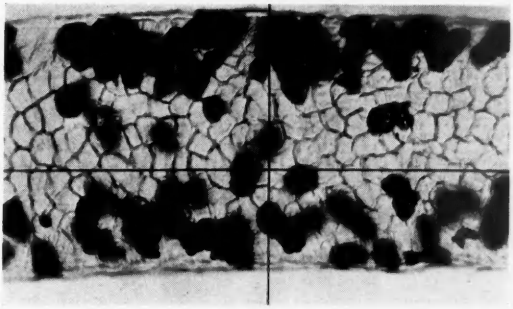

FIG. 20.

if the particles are of a darker color, the tube will still appear lighter in shade. There is much greater reflection of light from the glass-filled tube, or kemp, than from the solid tube, or wool, which makes the former appear lighter in color. Actual tests have proved [9] that the various dyes penetrate kemp just as readily as wool. Thus, when the enclosed air is removed, the cuticular, cortical, and medullary cells are all colored alike. The air inclusions prevent the color of the dye from being transmitted, since the fibres are rendered opaque by the air (Fig. 20).

* Strangeways and Roberts (*J. T. I.* T488, 1931) found more cortex in colored kemps than in white ones.

Efforts were made to dissect out a single kemp medulla cell. Physical dissection with drawn out glass needles, chemical methods using alkalis or acids, and bacteriological action were tried with poor success. Results were obtained, however, by scraping a lateral section of the fibre and suitably mounting the result. The cells were then examined at high magnification and appeared the same as in the fibre mounts. Moreover, even with an oil-immersion objective and incident light, no evidence of the "spinous projections" through the cell walls could be detected.[6] The presence of the cells, however, and the absence of any "hollow" effect in the fibre, in contradiction to Dr. Matos,[9] is positive.

Fig. 21 shows two views of the cells in the cross-section of a heavy kemp fibre. The reticulate structure of the cell walls, the shape and ar-

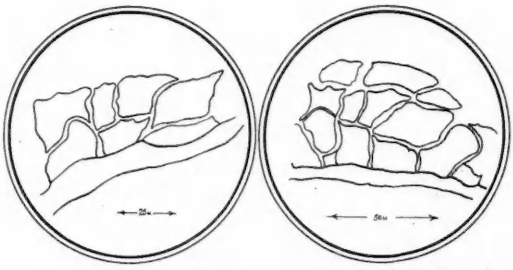

FIG. 21. Heavy kemp.

rangement of the cells themselves, and their position in relation to the cortical wall are all evident. The cell formation is continuous across the section, which, owing to the high magnification, was not drawn in complete. Fig. 22 illustrates the same thing in medium kemp. At the left is a view

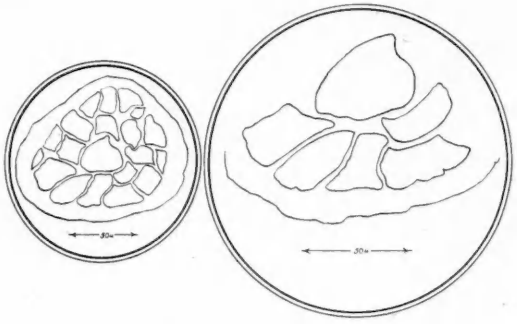

FIG. 22. Medium kemp.

of the complete cross-section; at the right, a higher magnification of a section of the one at the left. Both show cells, cell wall membrane, and the relation of cells to the outer covering. It is interesting to note that in many of these sections there was a close similarity in cell structure and arrangement to that given by Hohnel for hair.[9] Fig. 23 illustrates a wool

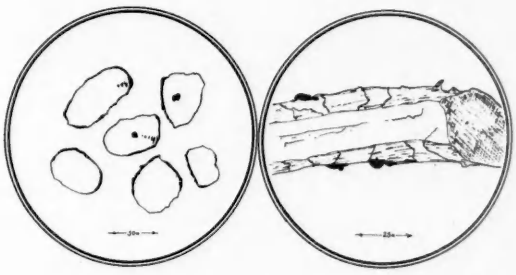

FIG. 23. Wool.

fibre; the view at the left is cross-sectional, that at the right a longitudinal split section. The cross-sections show the customary wool contour. Scale projection is evident, and in two of the sections the presence of a very fine medulla will be noticed. The view at the right shows the exposed interior of a wool fibre in lateral section, and the end at an oblique cut. The rough scales are very evident on the outside of the fibre, but no signs of cell formation is seen in either sectioned part.

## References

1. Gabriel, M. T. "The Cortical Cells of Merino, Romney, and Lincoln Wools." *J. T. I.*, T171 (1932).

2. Schwarz, E. R. "Textiles and the Microscope." McGraw-Hill, New York, 1934, p. 275.

3. Matthews, J. M. "The Textile Fibres." Wiley, New York, 1924.

4. Bowman, F. H. "Structure of the Wool Fibre." Macmillan, New York, 1908.

5. Roberts, J. A. F. "Kemp." *Ntl. Assoc. of Wool Mfrs. Bull.* July, 1927, p 354.

6. Duerden, J. E. "Kemp Fibres in the Merino." *J. T. I.*, T268 (1926).

7. Barker, S. G. "Wool Quality." H. M. Stationery Office (England), 1931, p. 264.

8. Hirst, H. R. and King, A. T. "Some Characteristics of Mohair Kemp." *J. T. I.* T296 (1926).

9. Matos, L. S. "Kemps—Source, Nature and Effect." *Tex. Wld.*, 65 (1928).

10. Priestman, H. "The Detection of Kemp Fibres." *Yorkshire Observer*, June 3, 1911. See also Bliss. "Kemp—A Review of the Literature." *J. T. I.*, T264 (1926).

# Abstracts

**This section is compiled under the direction of the Committee on Abstracts and Bibliography: Prof. E. R. Schwarz, Chairman, M. W. Weiss, Dr. Irving J. Saxl and C. H. Clark.**

## I. Fibres (Synthetic and Natural) and Fibre Analysis

(Rayon) Germany's Staple. Otto W. Bitzenhofer. *Tex. Wld.*, Oct. 1935, P. 74.

Describes new rayon and acetate cut staples, their physical properties and how they compare with natural fibres. (C)

Silk and Rayon During 1934. A Review of Technical Developments. *Am. Dye. Rptr.*, June 17, 1935, P. 355–7 (reprinted from *Silk J. and Rayon Wld.*). (C)

Staple Fibre Production: Technical Aspects of. (German.) H. Jentgen. *Die Kunstseide*, Nov. 1935, P. 389–401.

A rather comprehensive article covering the manufacture of staple fibre by the new process of Steimmig. According to this scheme, the viscose is produced continuously, cellulose paper being carried by a roller through sodium hydroxide solution, squeezed, ripened in a heated chamber, disintegrated and xanthated. After brief description of the spinning machines and different processes of after treatment, information is given as to the effects of different treatments upon the yarn itself. According to the author's experience, the influence of tension on the textile properties of the fibres and filaments is only of decisive importance in the spinning process itself. If the whole filament is once coagulated, tension during subsequent treatments cannot especially affect it, unless the tension is abnormally high and weakens the yarn. Small differences in strength and extensibility observed in the different processes are in the author's opinion significant. The author also believes that the dyeing properties of the fibres may be kept uniform from the beginning by taking the necessary precautions in spinning independent of the after treatments. (S)

Viscose: on the Theory of the Xanthate Formation and the Ripening of. L. Miras. *Die Kunstseide*, Oct. 1935, P. 348–51.

From experimental work carried out in the Rayon Laboratory of the Institute of Chemistry and Technology in Leningrad and in the laboratory of the rayon factory "Pjatiletka" the author draws several conclusions. Starting from the theory of the cellulose micelle he gives a picture of xanthate formation, arriving at the conclusion that in xanthating two

reactions run parallel: 1. the formation of the xanthate; 2. the formation of $Na_2CS_2$. The first reaction largely depends upon the water content of the alkali-cellulose. The number of $CS_2$-groups entering the micelle is determined by the degree of ripening of the alkalicellulose and by the temperature. Experiments carried out in the experimental station of the rayon factory "Pjatiletka" have proved the possibility of obtaining completely soluble xanthate by the use of 16% $CS_2$, provided that the temperatures are properly adjusted, thus confirming the statements of the French patent 430221. The author also shows that the oxygen in the air exerts a strong influence upon the ripening phenomena of viscose, ripening proceeding in a quite different way in an atmosphere of nitrogen. In the opinion of the author the essential feature of the ripening process is not to be seen in the splitting off of $CS_2Na$-groups but in colloidal phenomena hereby involved. By the splitting off of the $CS_2Na$-groups the hydrophobic properties increase and the reduction of the water envelopes around the micelles leads to the formation of secondary particles. (S)

X-RAY STUDY OF THE HYDRATION AND DENATURATION OF PROTEINS. W. T. Astbury and R. Lomax. *J. Chem. Soc.*, 1935, P. 846–51.

The following non-fibrous proteins were photographed both dry and after adsorption of water or alcohol—ordinary egg white, boiled egg white, serum albumin, serum albumin denatured by heat, pepsin, trypsin, zein, commercial casein, tobacco-seed globulin, squash-seed globulin, and edestin from hemp seed. In every case, the diffraction pattern, at atmospheric humidity, either consists solely of, or is based on, a pair of rings of roughly constant dimensions, and existing evidence suggests strongly that the inner ring is to be associated with the side-chain spacing, and the outer with the backbone spacing, of polypeptide chains. Where spacing changes occur on adsorption of water or alcohol vapour, it is the postulated side-chain spacing that increases most; the backbone spacing always remains unchanged, or nearly so. The change accompanying denaturation is simply a sharpening of the backbone reflection and the appearance of at least one other outer ring of spacing about 3.6 A. Denaturation greatly favours the backbone linkage, and also "tightens" the side-chain linkage and decreases its capacity for separation on the entry of water molecules. (From *J. T. I.*, Aug. 1935, P. A435.) (C)

X-RAY STUDIES OF CRYSTALLITE ORIENTATION IN CELLULOSE FIBRES. Natural Fibres. W. A. Sisson. *Ind. Eng. Chem.*, Jan. 1935, P. 51–6.

In well-oriented fibres it is impossible to determine whether the crystallites are arranged with a definite crystallographic plane always parallel to the face of the cell wall, or whether the crystallites are rotated at random around their own axes. However, it is shown that, in fibres having a wide deviation from a parallel orientation or a large spiral angle, it is possible to obtain information in this connection. If the crystallites have a random rotation around their own axes, the diffraction spots from the planes parallel to the fibre axis will be equal; if the crystallites are limited in their rotation, the spots will be unequal. From a study of the density distribution for several fibres and from the synthesis of various possible types of fibre diagrams, it is concluded that the crystallites of natural fibres have an unlimited rotation around their "b" axes in the face of the cell wall. These results appear to be best explained by the assumption of a definite discontinuity of crystalline structure. (C)

WOOL: REPORT OF SUB-COMMITTEE ON CHEMISTRY OF. Alban Eavenson. *Am. Dye. Rptr.*, June 3, 1935, P. 315–16.

This report of the Sub-committee on the Chemistry of Wool, presents an interpretative review of work done during 1934 by Milton Harris, a research associate of the A. A. T. C. C. working at the U. S. Bureau of Standards. (C)

WOOD PULP OR LINTERS. M. Wadewitz. *Tex. Wld.*, Aug. 1935, P. 88.

Abstract of paper presented at the New York meeting of the cellulose division, American Chemical Society. The author analyzes changing requirements for raw materials and other trends in rayon industry. (C)

## II. YARNS AND FABRICS

ACOUSTICAL PROPERTIES OF TEXTILES. Robert G. Silbar. *Tex. Wld.*, Aug. 1935, P. 66.

Describes and tabulates briefly tests made with different seats and coverings in a 1,500-seat theater made by acoustical department of American Seating Co. working in conjunction with the Bureau of Standards. Acoustical analysis of a room follows the formula of Prof. W. C. Sabine: $t = .05V \div a$, where $t$ = reverberation time in seconds; $.05$ = a constant; $V$ = volume of room in cubic feet, and $a$ = total absorption in the room. The problem is to reduce the reverberation time, $t$, until hearing conditions become satisfactory. This is done by increasing the total absorption, which in turn depends largely on the kinds of materials present—draperies, upholsteries, and carpets. (C)

FABRICS: TECHNIQUE OF RENDERING—ACTIVELY ANTISEPTIC. L. D. Clement. *Am. Dye. Rptr.*, June 17, 1935, P. 341–8. (C)

MECHANICAL PROPERTIES OF COTTON YARNS. H. F. Schiefer and D. H. Taft. *B. S. J. Rsch.*, Sept. 1935, P. 237–53.

The results of tests on three lots of cotton yarns are discussed. The breaking strength and elongation at rupture were determined by single-strand, multiple-strand, and skein tests. The variation in breaking strength, elongation at rupture, diameter, angle of twist, and irregularity of the yarns with the amount of twist are shown. The average breaking strength per strand and the elongation by the multiple-strand test are less than those by the single-strand test and greater than those by the skein test. The data were studied statistically and an explanation is given of the differences which were obtained by the different test methods. Twelve cones of the commercial yarn were tested for breaking strength by the single-strand test. A statistical study of the data indicates significant differences in the average breaking strengths between the different cones. (C)

METALLIC CONSTITUENTS IN TEXTILE FABRICS: SIGNIFICANCE OF. A. H. Pettinger. *Am. Dye. Rptr.*, June 3, 1935, P. 301–3. (C)

RAYON SIZES: IMPORTANCE OF HIGH MOLECULAR SUBSTANCES AS RAW MATERIALS FOR. (German.) Carl-Heinz Fischer. *Die Kunstseide,* Nov. 1935, P. 424–6.

The author reviews the most important modern international patents on the production of sizing agents for rayon and staple fibre. The so-called Bezet size and the Blufajo size together with the Silkovan K size are described in detail. The Bezet size is applied at 35 to 45° and may also be used on either the cylinder or hot air sizing machines. As the solution is said to be stabie, sizes which have been for a longer time in use can still be employed. The Blufajo size is a hydrolysis product of animal glue. It is not only sterile, but also germicidal and resistant to a tropical climate. According to whether warp sizing or ball warp sizing is used and according to the type of rayon, different types of this size are used. The Silkovan K size is applied at somewhat higher temperatures than the previous sizing mixture. It is resistant to lime and it also prevents the troublesome sticking together of the filaments. In the author's opinion, a sizing agent should be universally applicable to all kinds of rayon and staple fibres, readily soluble in water, indifferent to dyes and perfectly stable on storage; desizing before dyeing should be unnecessary. (S)

SIZING OF RAYON. Ernst Sauter. *Monatsh. Seide Kunstseide,* 1935, V. 40, P. 194–6; *J. T. I.,* Aug. 1935, P. A396; *C. A.,* 1935, V. 29, Col. 4949.

The heat of oxidation evolved during the drying of sized rayon is lower with sulfonated linseed oil than with ordinary linseed oil; this decreases greatly the fire hazard. Other advantages of the sulfonated oil are its soly. in nonaq. solvents, greater strength and easier removal from the sized material. Verapol soap gives good results for the removal of oil sizes. Several procedures are given for the proper removal of sizes. Warp yarns from artificial silk fibres are best sized with water-sol. products rather than with linseed oil or compns. contg. it. Good results are obtained with a size contg. 1000 l. of water, 40–60 kg. potato starch, 5 "Stoko tablets," 2–5 kg. tragacanth, 5–10 kg. "Tallosan" and 1–2 l. glycerol. For mixed yarns from rayon fibres and cotton it is advisable to increase somewhat the amt. of potato starch. The "Stoko tablets" hydrolyze the starch only as much as is necessary to bring about the proper sizing effect. The sizing machine is best kept at a temp. of 40–50°. (W)

SIZING PROBLEMS FOR RAYON CONSUMPTION: IMPORTANCE OF. W. Weltzien. *Monatsh. Seide Kunstseide,* 1935, V. 40, P. 193–4; *C. A.,* 1935, V. 29, Col. 4949.

The various difficulties in sizing rayon are enumerated and some of the methods devised for overcoming these difficulties are described. (W)

SIZING OF VISCOSE. H. Geier. *Monatsh. Seide Kunstseide,* 1935, V. 40, P. 198–200; *J. T. I.,* Aug. 1935, P. A397; *C. A.,* 1935, V. 29, Col. 4949.

For testing the sizing of viscose, Weltzien's app. and procedure are most suitable. Linseed-oil sizes, although most used, cause dyeing and finishing difficulties not encountered with water-sol. sizes. The water-sol. sizes are classified as (1) artificial rosin products (Vinarol, Silkovan A special, and Supra size), (2) starch products (Ortoxin and Rabic) and (3) protein products (Silkovan K and Blufajo). These sizes are compared in

regard to loss of elongation, increase in tear resistance, closure of fibre and Weltzien evaluation. Silkovan K gives good results. Vinarol and Silkovan K can be removed easily with warm water; Ortoxin can be removed only with the aid of special desizing agents. In their effect on weaving and dyeing qualities the sizes of group 3 and particularly Silkovan K are most satisfactory. (W)

Too Much Drawing: Worsted Mills are Simplifying the Process. H. A. Lawrence. *Tex. Wld.*, Sept. 1935, P. 90.

An article based on studies made in England, and substantiating some of the results obtained in experiments at Lowell (Mass.) Textile Institute (*Tex. Wld.*, Sept. 1934, P. 106). (C)

When to Stop Testing. A. E. Oxley, D.Sc. *Tex. Wld.*, July, 1935, P. 80–1.

Adequate sampling of raw materials, goods in process and finished products is important if tests are to mean anything. It is quite as important to know just how many tests are necessary before a sound conclusion can be drawn as to the strength, size, twist or other property of the fibre, yarn or fabric under investigation. The author gives a graphic method of recording results of tests that shows the point at which sound conclusions can be drawn and at which testing should be stopped. He correctly emphasizes that spread of irregularity values of the property measured, which he terms the "sub-mean irregularity," which is of special significance to the practical man. (C)

## III. Chemical and Other Processing (Not Otherwise Classified)

Absorption of Substantive Dyestuffs: Various Factors in the. A. M. Patel. *Tex. Mfr.*, 1935, V. 61, P. 71–3; *C. A.*, 1935, V. 29, Col. 2748, 4945.

A review is given of recent ideas on the dyeing of cotton and rayon with direct dyestuffs, in addn. to the conclusions from certain expts. It was observed that the dye was taken up more by mercerized than unmercerized oxycellulose. This amt. was less than that taken up either by bleached or mercerized cotton, up to a certain salt concn. Beyond that, the absorption by mercerized oxycellulose was more than by bleached cotton. By this process, if tendered cloth is mercerized, the strength is restored and the damage masked by dyeing to a moderately heavy shade. (W)

Acetate Rayon: Production of Many-colored Effects in Mixed Goods Containing. W. Kegel. *Monatschr. Textil-Ind.*, 1935, V. 50, P. 123–4.

Directions are given for dyeing mixts. of acetate rayon in various combinations with cotton, silk, wool and other rayons. (From *C. A.*, 1935, V. 29, Col. 5276.) (W)

Bleaching of Cotton: Decomposition of Hydrogen Peroxide in Alkaline Solution and Its Importance for the. Chr. Dörfelt. *Monatschr. Textil-Ind.*, 1935, V. 50, P. 37–40, 67–70, 90–3, 117–19; *C. A.*, 1935, V. 29, Col. 5278. (W)

BOILING AND BLEACHING OF COTTON BY HYDROGEN PEROXIDE FOR OBTAINING HYDROPHILIC COTTON WITHOUT BOILING UNDER PRESSURE. W. Fehre and M. Audoynaud. *Arhiv Hem. Farm.*, 1934, V. 8, P. 179–84; *C. A.*, 1935, V. 29, Col. 5279. (W)

COTTON HAIR: MERCERIZATION. H. Reumuth. *Z. ges. Textilind.*, 1935, V. 38, P. 21–4 (through *Chem. Zentr.*, 1935, i, P. 2282).

The author describes, with the help of photomicrographs and kinematograph films, the changes accompanying mercerization. Dry cotton is incompletely mercerized after three minutes in lye without a wetting agent but a much better effect is secured if 15 cc. of Floranit HF is added to each litre of 30° Bé lye. (From *J. T. I.*, Aug. 1935, P. A406.) (C)

COTTON YARN: EFFECT OF SULFUR DIOXIDE FUMIGATION ON THE STRENGTH OF—Dyed with Sulfur Black "Ch. F." D. N. Gribоedov. *J. Applied Chem.* (U. S. S. R.), 1934, V. 7, P. 980–8; *C. A.*, 1935, V. 29, Col. 5663. (W)

DETERIORATION OF VEGETABLE OILS BY OXIDATION. Herman A. Holz. *Paint Varnish Production Mgr.*, June, 1935, P. 12; *C. A.*, 1935, V. 29, Col. 4956.

The "age limit" of materials such as insulating varnishes and printing inks, can be anticipated by exposing them directly to the influence of O in an app. supplying the O under carefully standardized conditions. The oil or other liquid is poured on a calibrated catalyst and exposed to the action of O at 100°. The O is produced in the app. itself, in the same quantity as absorbed by the material under test. The elec. current required to produce this quantity of O is measured and the data thus obtained represent an exact measure of the "oxidizability" of the material. The app. shows how much O can be absorbed in a certain period, and gives a definite measure of the tendency to deteriorate. The test period for a complete aging curve is 100 min., while for simple control analyses 30 min. is sufficient. The quantity of material for one test is 15.5 g. (W)

DYE VARIATIONS: CAUSE OF EXCESSIVE—ENCOUNTERED IN FABRICS CONTAINING "CABLE TWIST" YARN. B. L. Hathorne. *Am. Dye. Rptr.*, 1934, V. 23, P. 608–9. (W)

DYEING OF COTTON AND THE SUBSTANTIVITY OF COLORING MATTERS. A. Wahl. *Rev. gen. mat. color.*, 1935, V. 39, P. 161–6; *C. A.*, 1935, V. 29, Col. 5275.

Review of recent literature. (W)

DYEING TECHNIC AND THE BLEACHING OF THE VISTRA FIBRE AND OF THE MIXED YARNS MANUFACTURED FROM IT. A. Fritsch. *Z. ges. Textil-Ind.*, 1935, V. 38, P. 239–41. (W)

DYESTUFF INTERMEDIATES: METHODS OF ESTIMATING—BY COUPLING. I. Selection of Diazo Solutions for Coupling and Accurate Methods of Estimating Dyestuff Intermediates. S. Ueno and H. Sekiguchi. *J. Soc. Chem. Ind., Japan* 38, Suppl. binding, 1935, P. 142–4; *C. A.*, 1935, V. 29, Col. 4945. (W)

DYESTUFFS: IDENTIFICATION OF. T. W. Whattam. *Am. Dye. Rptr.*, 1935, V. 24, P. 239–42, 262. (W)

EMULSIONS: SCIENTIFIC ADVANCE IN—FOR THE TEXTILE TRADE. W. E. Billinghame. *Tex. Mfr.*, 1934, V. 60, P. 45; *C. A.*, 1935, V. 29, Col. 4180.

An emulsion should be regarded as a 3-phase system and not as a 2-phase system. (W)

FASTNESS OF CERTAIN AMINOAZO DYES TO WASHING. J. C. Earl and H. M. Parkin. *J. Proc. Roy. Soc. N. S. Wales*, 1935, V. 60, P. 110–11. (W)

FLUORESCENCE TESTS FOR THE MERCERIZING OF COTTON AND RETTING OF FLAX. O. Mecheels and E. Gruensteidl. *Tex. Mfr.*, 1934, V. 60, P. 434.

The tests, using dyes, are briefly described. In flax retting they are not applicable to chemically retted fibres. (From *C. A.*, 1935, V. 29, Col. 4589.) (W)

GAS FADING. F. L. Goodall. *J. Soc. Dyers Col.*, 1935, V. 51, P. 126–7; *C. A.*, 1932, V. 26, P. 5763; 1935, V. 29, Col. 3843.

The failure of blue rayon materials kept in storage or displayed in shop windows is considered from three points. The blue dyes for cellulose acetate rayon at present on the market are sensitive to acid; they show considerable sensitivity to exposure under damp conditions and color changes taking place in the dark. Faults caused by daylight failure can be restored by $NH_4OH$ while the failure taking place in the dark is due to coal gas. Convincing evidence is found that failure is due to oxides of N rather than to $SO_2$. The action is due to reaction of the oxides with the cellulose itself. (W)

GELATIN SOLS: EFFECT OF ELECTROLYTES ON pH. W. Giedroyć *Roczniki Chem.*, 1934, V. 14, P. 1409–17 (through *Chem. Zentr.*, 1935, i, P. 2545.

The effect of chlorides of Na, K, Ca and Mg, sulphates of Na and Mg, Na acetate and K oxalate on the pH of solutions of hydrochloric acid, alone and with gelatin, is described in detail. At pH's below the isoelectric point of gelatin the change in pH increases in the order $Cl < SO_4 < Ac. < Ox.$, both in the absence and in the presence of gelatin. In the presence of gelatin the effect is smaller, probably owing to buffer action. (From *J. T. I.*, Aug. 1935, P. A433.) (C)

GLUCOSE: USE OF—IN DYEING WITH THE ARYLAMIDES AND SUBSTITUTED ARYLAMIDES OF 2, 3-HYDROXYNAPHTHOIC ACID. G. H. Frank. *J. Soc. Dyers Col.*, 1934, V. 50, P. 14; *C. A.*, 1935, V. 29, Col. 4946.

Glucose may be used instead of $CH_2O$ for stabilizing naphthol solns. used in dyeing with ice colors. (W)

IMPREGNATION TECHNIC: NEW PROBLEMS OF THE—INVOLVING SINGLE-BATH IMPREGNATIONS. Günter Rordorf. *Monatschr. Textil-Ind.*, 1935, V. 50, P. 20–1, 43–4.

A discussion of various procedures and special cases dealing with single-bath impregnation agents as ingredients of special finishing opera-

tions, as protection against spots caused by drops and as a guard against shrinking. (From *C. A.*, 1935, V. 29, Col. 3524.) (W)

JUTE: DYEING, BLEACHING AND CHEMICAL TECHNOLOGY OF. B. D. Varma. *Indian Tex. J.*, 1935, V. 45, P. 201–3; *C. A.*, 1935, V. 29, Col. 4947.

The varieties and cultivation of jute are outlined, also retting and stripping, and special attention is given to bleaching. Hypochlorite, $Na_2O_2$ and $MgSO_4$, $Na_2O_2$ and $H_2SO_4$, and $KMnO_4$ and $H_2SO_4$ are the bleaching processes applied to jute. (W)

KIER-BOILING EFFICIENCY. F. Scholefield and D. Ward. *J. Soc. Dyers Col.*, 1935, V. 51, P. 172–8; *C. A.*, 1935, V. 29, Col. 5662.

This paper deals with the NaOH boil with an assistant of the sulfated aliphatic alc. type. Comparison is made with rosin soap. (W)

STARCH AND GLUE IN THE TEXTILE INDUSTRY. Fritz Ohl. *Gelatine, Leim, Klebstoffe*, 1935, V. 3, P. 51–4.

A general, non-crit. review of the use of starch and animal glue in finishing textiles. Potato starch is the most widely used although rice starch and wheat starch would enter except for price differential. Sol. starches are favored because they penetrate the fibre readily but they are too soft and hygroscopic for hard finishes. Dextrin is used in cotton finishing often in conjunction with animal glue. Animal glue is commonly employed in finishing rayon. (From *C. A.*, 1935, V. 29, Col. 5279.) (W)

STARCH PASTE: FORMATION. W. W. Lepeschkin. *Kolloid Z.*, 1935, V. 70, P. 312–3.

The formation of starch pastes involves two processes: a chemical reaction between water and the starch polysaccharides which leads to the formation of hydrates and swelling of the products (amylose and amylopectin) in water. When air-dried starch granules containing water of imbibition are heated strongly for a short time they acquire the property of swelling in cold water. Heating starch in a few aqueous media which hinder the swelling, *e.g.*, saturated potassium carbonate solution, produces the same result. Although the temperature coefficient of the reaction between starch polysaccharides and water is very high, there is no well-defined pasting temperature but rather a temperature zone of paste formation. The time required for the production of a fixed pasting phase at a given constant temperature can be measured. (From *J. T. I.*, Aug. 1935, P. A426.) (C)

STARCH SOLS: ORIENTED COACERVATION. H. G. Bungenberg de Jong. *Proc. Kon. Akad. Wet.*, Amsterdam, 1935, V. 38, P. 426–34.

In comparison with glycogen, the behaviour of soluble starch sols on addition of alcohol is more complex, owing to the presence of various colloid fractions with different properties. There is, in addition to a fraction corresponding in its colloid chemical behaviour to glycogen, a fraction that exhibits an oriented coacervation. If the coacervate sol is heated, very thin hexagonal plates separate out, forming a platelet sol. The properties of this sol are discussed. Reference is made to the formation of oriented coacervates with other desolvating agents. (From *J. T. I.*, Aug. 1935, P. A430.) (C)

STARCH SUBSTRATES: PREPARATION FOR AMYLASE DETERMINATIONS. W. R. Thompson. *J. Biol. Chem.*, 1935, V. 109, P. 201–2.

In the preparation of starch substrates for amylase determinations, it is permissible to store the autoclaved soluble starch solution up to five days at 25° C. Before proceeding according to the standard technique, the stored solution is heated just to the boiling point. (From *J. T. I.*, Aug. 1935, P. A429.) (C)

STARCH: PREPARATION AND PROPERTIES. *M/cr. Guard. Comm.*, 1935, V. 30, P. 371.

The extraction of potato and corn starches is described and various new starch products are discussed. Starches with small granules give pastes of higher viscosity and lower acidity than pastes made from large granules. A new source of small granule starch has been found in sweet potatoes; the granules are less than half the normal average size and starch pastes prepared from this form retain their viscosity on prolonged heating much better than ordinary forms of potato starch. In sizing the smallest granules penetrate between the fibres while the larger ones form a layer or coating over the material. The addition of 3% calcium borate, either after or during manufacture, is recommended in one method for rendering starch capable of swelling in cold water and increasing the strength and stability. Fungi will not appear in pure starch if kept in lac-lined drums or in tin-plate vessels but wood or galvanized iron is liable to cause deterioration. (From *J. T. I.*, Aug. 1935, P. A396.) (C)

TEXTILE DYEING TRADE: PROBLEMS OF THE. L. P. Rendell. *J. Soc. Dyers Col.*, 1935, V. 51, P. 208–11; *C. A.*, 1935, V. 29, Col. 5661.

A discussion of two-color dyeing and the dyeing of union materials. The latter include: viscose rayon and unmercerized cotton, viscose rayon and mercerized cotton, hollow-filament viscose rayon and cotton, cuprammonium rayon and cotton, cellulose acetate rayon and cellulose fibres, silk and cotton and regenerated cellulose, silk and cellulose acetate rayon, and silk and wool. (W)

## IV. RESEARCH METHODS AND APPARATUS

ANTIMONY ELECTRODES FOR pH MEASUREMENTS. P. Wulff, W. Kordatzki and W. Ehrenberg. Zeits. f. Elektrochem. 41, Aug. 1935, P. 542–9; Disc., 550–1.

The experiments were carried out on the irreversible electrode system $Sb + O_2 + H^+aq$. The potential values were determined in presence of air since an air free Sb electrode has no practical advantage over electrodes in common use. The experiments show a complicated mechanism for the formation of $O_2$ reduction and Sb oxidation products which depends on the character of the solution, the pH value, stirring and diffusion, and on the nature of the surfaces. The Sb electrode is subjected to a slow oxidation process which produces 3- and 5-valent Sb. A reaction product separates on the surface of the metal and this influences the potential, as also does the partial pressure of $O_2$ and, under certain conditions the movement of the electrolyte. These relations, especially the quantitative ones, show that in the presence of air the potential cannot be determined by the $Sb^{+++}$

activity of the solution, but by the irreversible oxidation process, and that the speed of diffusion of the reaction products must be considered at the electrode surfaces. Some hints are given for the practical employment of Sb electrodes. (From *Science Abs.*, Oct. 1935, Col. 4376.) (X)

EXTENSOMETER COMPARATOR. A. H. Stang and L. R. Sweetman. *B. S. J. Rsch.*, Sept. 1935, P. 199–203.

An extensometer comparator for the calibration of extensometer compressometers, micrometer dials, and strain gauges is described. The comparator has given satisfactory results in calibrating length-measuring instruments used for testing materials. (From *Science Abs.*, Oct. 1935, Col. 4097.) (X)

GLASS ELECTRODES FOR pH MEASUREMENTS. K. Schwabe. Zeits. f. Elektrochem. 41, Sept. 1935, P. 681–94.

The paper gives a comprehensive survey of the field covered by the employment of glass electrodes for pH measurements from Nernst until the present day. It deals with the various aspects of the problem including the form of the electrodes, the technique of measurement, the electrode functions and their uses. A long Bibliography is appended. (From *Science Abs.*, Oct. 1935, Col. 4377.) (X)

ISOELECTRIC POINT OF GELATIN. R. A. Dulitzkaja and S. I. Sokoloff. *Kolloid Z.*, Aug. 1935, P. 205–11.

To determine why the isoelectric point of gelatin varies according to its mode of production the isoelectric point of three kinds of gelatin has been determined, namely for (1) "Goldmarke" gelatin (Kahlbaum); (2) that made by treating pigskin with alkali ash, and (3) a gelatin derived from the same source but treated with acid instead of ashes. The determinations were carried out by the catalphoretic process, the nephelometer and viscometer. The average values obtained for the isoelectric point are for "Goldmarke" 4.87; for ashed gelatin from pigskin, 5.09; and for acid treated gelatin, 5.65–6.08. For the first two gelatin samples, the three methods gave identical results, but for the acid-treated gelatin distinct deviations in data were obtained; indeed, the cataphoretic method can be distinguished from the indirect methods. Potentiometric investigations of all three gelatins were carried out and these showed a characteristic difference of the acid and alkali quantities bound to the gelatin. It is deduced that natural, unchanged (non-ashed) collagen has a higher isoelectric point than gelatin and that the lowering of the isoelectric point by partial hydrolysis can be put down to a change in ratio of acid and basic groups. The degree of hydrolysis can vary and is higher by potash treatment than by acid treatment. (From *Science Abs.*, Oct. 1935, Col. 4056.) (X)

RAYON: ESTIMATION OF—IN MIXTURES OF RAYON AND COTTON. Antonio Angeletti. *Ann. chim. applicata*, 1935, V. 25, P. 117–20.

The method of Krais and Markert (*C. A.*, V. 25, P. 5994) has been modified slightly. A soln. of 80, instead of 100 g $Ca(CNS)_2$/100 cc. $H_2O$ is used so that the b. p. of the soln. is exactly 120°, and is made just acid with AcOH. Under these conditions, rayon is dissolved, while cotton is not. Wool also is not affected by the above reagent, and can also be sepd. from rayon. (From *C. A.*, 1935, V. 29, Col. 6431.) (W)

SILK AND RAYON: COMPARATIVE LOAD AND STRETCH TESTING WITH. (GERMAN.) K. Langer. *Die Kunstseide,* Aug. 1935, P. 262–6.

Real silk and rayon were compared as to elastic and permanent extension, elastic after effect, breaking strength, and breaking extension. Viscose, cuprammonium, and acetate rayon of different origin were examined and tables and charts are given. Explanation is also offered of the working up of the load stretch diagram to determine the elasticity, the elastic after effect and other items of interest in connection with the physical properties of the materials. In this series of tests work was done either at a constant rate of loading or at a constant rate of extension. There were no hysteresis curves or loops plotted and the results insofar as plastic effects are concerned are therefore incomplete. (S)

RAYON BY MICROSCOPICAL METHODS: ON THE DETERMINATION OF DENIER OF. (GERMAN.) Dr. A. Herzog. *Die Kunstseide,* June 1935, P. 186–94.

The author gives the results of an exhaustive series of tests on rayons of all four types from a series of manufacturers which enables the deduction mathematically of the necessary constants to use in the formulae for computing the legal denier of individual filaments of the various types of rayon. A convenient chart is given so that when the actual area of the cross section at 1500 diameters is known (having been determined by planimetering the area at this magnification) the denier may be directly found on the chart by reading across a series of scales. The chart is produced in negative form so that it may be easily photographed into positive chart for direct use. Details of the technique are outlined and a large number of charts and tabulated units of data are available. (S)

VISCOSE SPINNING ESTABLISHMENTS: QUANTITATIVE DETERMINATION OF TOXIC GASES IN. Dr. H. Frauenhof. *Die Kunstseide,* Oct. 1935, P 344–5.

In order to be able to install the ventilation devices at the right places and with maximum efficiency it is important to determine $H_2S$ and $CS_2$ content in the air of the different working-rooms of a rayon factory. For the determination of $CS_2$ the author proposes 10% alcoholic potassium hydroxide solution. The potassium xanthate formed is either precipitated by normal $SuSO_4$-solution as copper xanthate, a solution of guajac resin being used as indicator, or transformed into dixanthate by iodine-solution, with starch solution as indicator. $H_2S$ is equally determined by iodine-solution according to the equation: $H_2S + J_2 = 2\ HJ + S$. The necessary laboratory apparatus is illustrated by a design. (S)

VISCOSE RAYON: DETERMINATION OF OIL CONTENT OF. K. Langer. *Die Kunstseide,* Oct. 1935, P. 345–7.

In the Bisfa and Ral methods the prescriptions are in general not valid for oiled rayon. Fine filament rayon, however, is now often oiled in winding, twisting, etc., as the rayon factories must deliver the material ready for further working on conical or cylindrical cross-wound bobbins or on double-flanged bobbins. Hence the material contains a certain amount of oil, which is again washed out during dyeing. This is frequently the cause of differences of opinion between the rayon factory as seller and the knitter as purchaser, as to the weight of the rayon sold. The author has now es-

tablished the best method for the determination of the oil-content. Four different methods were used. He arrives at the conclusion that etherextraction in a Soxleth-apparatus leaves 0.70–1.21% oil in the rayon filament, according to whether the filament has been previously dried at 105° or not, and that the complete removal of oil is only possible by a washing process. (S)

## V. Economics, Physics and Miscellany

Colloidal Solutions: Preparation of—by Silent Electric Discharges. Part III. S. Miyamoto. *Kolloid Z.*, June 1935, P. 297–300.

The methods previously employed for the preparation of the sols of Au, Ag, Pt, Pd, As, Sb and Hg are now used for the preparation of hydrosols of $MnO_2$, Te and alcosols of Se and Te. The stability of these sols is investigated. (From *Science Abs.*, Sept. 1935, Col. 3732.) (X)

Electrokinetic Potential and the Stability of Colloids. H. Mueller. *J. Phys. Chem.*, June 1935, P. 743–7.

Mathematical and experimental considerations are given to the origin and nature of the protecting skin assumed to exist around every colloidal particle, according to March. The proposed theory is shown to explain the dependence of the stability of hydrophobic colloids on the electrokinetic potential. (From *Science Abs.*, Sept. 1935, Col. 3733.) (X)

Hydrogen: Function of—in Intermolecular Forces. J. D. Bernal and H. D. Megaw. *Roy. Soc. Proc.*, Sept. 2, 1935, P. 384–420.

From a consideration of the known crystal structures of the metallic hydroxides, it is shown that the force between hydroxyl groups is a function of the size and charge of the kation with which they are linked. When the ion is small and highly charged this force acquires the character of a secondary valency only less powerful than the H bond of acids. This bond, of length about 2.7–2.8 A, is called the hydroxyl bond, and an attempt is made to explain its occurrence in terms of changes in the internal electronic structure of the hydroxyl group. As in ice, the polarised hydroxyl group is assumed to have a tetrahedral structure with a negative region which serves to bind the positive H atom of a neighbouring hydroxyl. The hypothesis of the hydrogen bond is used to interpret the structures of complex hydroxides and in one case, $Te(OH)_6$ to predict the structure. Possible applications of the idea to organic and colloid chemistry are suggested. (From *Science Abs.*, Oct. 1935, Col. 4051.) (X)

Interfacial Tension. D. G. Dervichian. *Compt. Rend.*, July 29, 1935, P. 333–4.

The relation $\gamma_{AB} = \gamma_A' - \gamma_B$ is deduced from a consideration of the forces exerted in separating two liquids A and B at an interface, the liquids being such that the molecular forces between the two liquids exceed those in the liquid B. $\gamma_A' = \gamma_A - p$ is the reduction of surface tension of A due to the monomolecular layer of B detached on A. Antonov's rule therefore holds for both miscible and non-miscible liquids, provided $\gamma_A'$ is substituted for $\gamma_A$. Further consideration leads to an indication of the possibility of the existence of negative interfacial tension. (From *Science Abs.*, Oct. 1935, Col. 4122.) (X)

SUPERSONIC PULVERIZER. B. Claus. *Z. f. techn. Physik*, 1935, V. *16*, P. 202–5.

Describes the construction of a pulverizer which makes use of the property of piezo-quartz plates to produce oscillations, two parallel quartz plates being used and tuned to the same wave-length. The apparatus is dealt with under the oscillator, the transferer, the producer and the method of assembly. Finally, methods of use are considered, dealing with the two possibilities of direct and indirect pulverizing. (From *Science Abs.*, Sept. 1935, Col. 3734.) (X)

SURFACE TENSION AND SOLVATION. H. G. Trieschmann. *Z. f. phys. Chem.*, 1935, V. 29B, P. 328–34.

On the basis of measurements of the surface tensions of mixtures of alcohols with various solvents, a molecular interpretation is given relating the phenomena of surface activity with the degree of solvation. The theory is tested against the available data. (From *Science Abs.*, Oct. 1935, Col. 4125.) (X)

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## BOOK REVIEWS

1934 YEAR BOOK OF AMERICAN ASSOCIATION OF TEXTILE CHEMISTS AND COLORISTS. Howes Publishing Co., Inc., New York, N. Y., 495 pp. $3.00.

In addition to its regular features, all of which are much more complete than heretofore, and the usual annual reports of the research committee and its various sub-committees, are very complete bibliographies of the following subjects: Publications of Research Committee; books in English on textile chemical subjects since 1900; on subjects pertaining to "The Study of Shrinkage and Luster in the Mercerization of Cotton." (C)

A. S. T. M. STANDARDS ON TEXTILE MATERIALS. American Society for Testing Materials, Philadelphia, Pa. 246 pp. $1.50.

This 1935 compilation of A. S. T. M. standards on textile materials has been extensively revised and amplified. It contains also a psychrometric table for relative humidity, a convenient yarn number conversion table, a section containing a number of photomicrographs of common textile fibres, and abstracts of a number of papers read at D–13 meetings. (C)

DIET AND PHYSICAL EFFICIENCY. Howard W. Haggard, M.D., and Leon A. Greenberg, Ph.D. Yale University Press, New Haven, Conn. 180 pp. $3.00.

A careful and revealing study of the influence of the frequency of meals upon physical efficiency and industrial productivity. The authors are associated with the Department of Applied Physiology, Yale University. Their book is based upon a series of actual experiments carried out in a factory at Naugatuck, Conn. They found that on the same amount of food the industrial output of factory operatives may be as much as 10% greater under one mealtime arrangement than under another. The value of the book is heightened by a very complete bibliography and a well-arranged index. (C).

(*Editorial continued from page 142*)

## Meeting of Research Council

AT a meeting of the Research Council of U. S. Institute, held in New York City, Dec. 13, the following research subjects were assigned and in several cases are already in progress: Moisture regain; rapid dyeing of acetate rayon; automatic color matching; measurement of finish; mechanics of adsorption and desorption; detection and removal of impurities in finished fabrics and finishing materials; the drying of textile fibres and products.

It was decided that progress in wear testing of textile products has been and is likely to be most resultful when confined to a single class or allied classes of products and conducted by interested groups, and that a basic scientific study of general character should await the accumulation of such specialized data. It was, therefore, voted that the subject of the wear of fabrics and wear testing be dropped from U. S. Institute's list.

The report of the committee in charge of the open conference on rayon crêping problems, held under U. S. Institute auspices Nov. 14, was accepted as clearly indicating the need of a scientific study of the subject for the purpose of discovering and defining fundamental principles. It was decided, however, that the subject be held in abeyance by U. S. Institute until there is a well-defined demand from the industry for such a study.

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## Glass Yarn and Textiles

THOSE textile manufacturers who admit that scientific research may be good for the other fellow, but not for them, are facing another interesting competitive example of the truth of this admission. One of the concerns long engaged in the manufacture of glass, the Owens-Illinois Glass Company, has, after months of research, perfected a process of drawing glass into fibre capable of wide application.

This company claims that it is now practical to think of living in homes and working in buildings built of glass--blocks, insulated against heat and cold by glass "wool," with air entering through warm-air furnaces and ventilating systems cleaned by fibrous glass filters, electrical illumination flowing through wires insulated with glass threads, and having carpets, curtains and other articles woven of glass.

The blocks, so it is said, permit up to 86 per cent of outside light to enter without glare. They would be placed so as to bend the light rays upward, across the room or toward the floors as controlled by the pattern on the face of the blocks. Diffusion and non-conductivity of glass would enable such masonry to reduce temperatures due to direct sunlight. The

glass "wool," like mineral "wool," is fireproof and vermin proof. The glass filters are sprayed with a non-evaporating chemical which catches the dust. It is claimed that such filters prove helpful to hay fever sufferers.

## Synthetic Wool from Casein

ACCORDING to a report from the Rome office of the U. S. Bureau of Foreign and Domestic Commerce, regarding the synthetic wool produced in Italy from casein, the inventor of the process is Comm. Antonio Ferretti, Via B. Marcello 16, Milano. The casein is prepared in the establishments of the Milan Milk Producers Consortium, and the fibre itself is produced, spun and woven at the Cesano Maderno plant of the Snia Viscosa.

Casein extracted from skimmed milk by the usual method is subjected to a bath of chemicals in which it is soluble, and the resulting viscous solution is forced through spinning nozzles as in the manufacture of rayon. In fact, except for the chemical treatment, for which special apparatus is required, the new synthetic wool is produced with the same equipment used in the production of rayon. It is said that one kilo of coagulated skimmed milk gives one kilo of yarn. Information supplied by the inventor of the process stated that synthetic wool has the same properties as natural wool. The chemical composition * is given as follows:

| | Natural Wool % | Synthetic Wool % |
|---|---|---|
| Carbon | 49.25 | 53.00 |
| Hydrogen | 7.57 | 7.00 |
| Oxygen | 23.66 | 23.00 |
| Nitrogen | 15.86 | 15.50 |
| Sulphur | 3.66 | 0.70 |
| Phosphorus | —— | 0.80 |
| | 100.00 | 100.00 |

It is stated that, owing to the smaller percentage of sulphur, which tends to reduce the warmth of natural wool, the synthetic wool possesses even greater heat-conserving qualities than natural wool, and that, furthermore, the absence of sulphur makes the new fibre take the dye more evenly. The synthetic wool can be produced in the fineness and length of staple desired, thus, it is claimed, assuring the highest degree of perfection in the finished textiles.

Production costs vary according to the price of casein it is stated. The manufacturing cost, apart from the casein, works out to about Lire 1.50 per kilo, of which about 50 centimes cover the cost of the chemicals used. The manufacture of the new synthetic wool has already passed the experimental stage and is being carried out on an industrial scale. It is stated that by January the output in the Snia plant is expected to be 5,000 kilos daily and 25,000 kilos per day by next June.

* While the chemical components of this so-called "synthetic wool" may be accurate, it will be necessary to await a scientific analysis of its physical characteristics before deciding whether it really merits the term "synthetic wool." Such tests as were possible with the small samples that were available indicate that it lacks several of the physical characteristics that differentiate wool from other natural fibres.—Editor.